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PROF. HICKS'S PRESIDENTIAL ADDRESS.

THOSE who are interested in molecular theories will find in Prof. Hicks's Address to the Mathematical and Physical Section of the British Association a mine of suggestive ideas. The principal subject of the Address was the vortex atom theory of matter, and the vortex sponge theory of the ether.

The elastic solid theory of the ether which has so long served as the basis of our theories of light and electricity appears to have had its day. As Prof. Hicks remarks, "there are difficulties connected with it—especially in connection with reflection and refraction—which decide against it." The rotational theories appear to meet these difficulties. MacCullagh was the first to work out a mathematical theory of rotational ether, and since then Kelvin, Hicks and Larmor, have worked at the same subject. The aim of these theories is to show how the ether may possess such elastic properties as will enable it to transmit the transverse waves of light and electricity, while it, at the same time, allows masses of matter to move freely in it as if it were a gas. The rotation of a fluid in vortices is the only way in which we can imagine it may acquire the required quasi rigidity without actually becoming a solid.

The vortex theories of the ether appear to have grown out of the vortex atom theory proposed in 1867 by Lord Kelvin. Since that time, mathematicians have continued the investigation of this fascinating theory, and have deduced many interesting results, though the mathematics of the subject appear to offer, as yet, insurmountable difficulties to a complete determination of the properties of the vortex atom. Prof. J. J. Thomson has shown that the vortex atom theory is capable of serving as the basis of a kinetic theory of gases. It has been considered a fatal objection to this theory that the translation velocity of the vortex atom decreases, as the temperature of the gas rises. But, as Prof. Hicks justly remarks, it has never been experimentally proved that the velocity of an atom increases with temperature. The objection is an example of the common error of introducing into a new theory ideas derived from one totally different. As the energy of a vortex ring decreases, the aperture becomes smaller, the filament thicker, and the velocity of translation greater. The behaviour of the ring can be traced until the thickness of the ring has increased to about four times the diameter of the aperture. Then the mathematical treatment employed fails. Another page has been, however, recently added to the history of the contracting vortex ring by the discovery of the spherical vortex by Prof. Hill. This is probably the form which the vortex ring takes when the contraction has gone so far that the aperture disappears. As the energy is still further reduced, its history is again interrupted, but it now lengthens out, and towards the end of its course approximates to the form of a rod moving

parallel to its length through the fluid, with energy and velocity, which can again be approximately determined. In this part of its life the velocity of translation decreases with the decrease of energy. The spherical atom is probably the stage where this reversal of property takes place.

One of the prettiest results of Prof. J. J. Thomson's investigation of the vortex ring atom, is his explanation of chemical reactions. The explanation of chemical affinity is one of the great difficulties with the ordinary atomic theories. To meet this difficulty, such strained hypotheses have been invented as that one-half the atoms have positive charges of electricity, and the other half have negative charges, whereas everything else points to the conclusion that all the atoms of the same substance are exactly alike. The vortex atom theory gets over this difficulty, and, moreover, gives a remarkably pertinent explanation of the valency or different combining power of the atoms of different elements. When two vortex rings of the same strength, and nearly the same diameter, come near each other, they link together, by each darting alternately through the centre of the other. An atom or molecule, consisting of two linked rings, behaves like a single ring of double the strength, one of three links, of three times the strength, and so on. J. J. Thomson has shown that it is not theoretically possible for more than six rings thus to link or combine together. This must at least be looked upon as a remarkable coincidence with the fact that six bonds is the maximum number ascribed by chemists to any of the atoms. The explanation of the well-known fact, that the presence of a third substance will often cause chemical combination between two others, which would not otherwise combine, is equally good. The third atom acts as an intermediary between the two reluctant atoms, who will not combine on account of the too great difference in their diameters; the third atom has an intermediate diameter, and by linking alternately with each, causes their diameters to approximate within the combining limit. The energy of rings combined or linked together, is less than when they are free, and consequently an expenditure of energy is required to dissociate them.

Maxwell's objection to the vortex atom theory was that it failed to explain the mass or inertia of matter. The density of the ether, which forms the substance of the vortex atom, is usually considered to be enormously less than that of matter, and nothing is added to its density by setting it swirling in a vortex ring. This extreme tenuity of the ether is, of course, merely an assumption necessitated by the older theories, and Prof. Hicks cuts the knot by boldly assuming that the ether has a sufficient density to account for the mass of matter. And why should he not? One of the consequences of this assumption is that the energy contained in one cubic centimetre of the ether is sufficient to raise a kilometre cube of lead 1 metre high against its own weight. Why should we not also accept that, since we know of nothing to the contrary?

Prof. Hicks has applied his theories to the explanation of electrical and magnetic reactions; but his explanations appear to be somewhat wanting in simplicity. For instance, to explain the twisting of the plane of polarisation of light in the magnetic field, a new vortex ring has to be invented, with a superadded longitudinal circulation through its core. To explain gravitation, a vortex ring with a hollow core is required, which, by its expansion and contraction, produces strains in the surrounding vortex sponge ether, and thus creates the field of varying pressure required to produce the gravitating force. As there is no difficulty in producing vortex rings in gases or liquids, this interesting subject seems to be now ripe for a little experimental investigation, which might, at least, serve the end of keeping mathematical investigation on the main track, and preventing it wandering off and losing itself in labyrinthan sidepaths.

Alternating Currents.

Ten years is much in a man's life; it is more in the history of electrical engineering. Ten years ago the alternating high tension system of distribution had only just taken up its abode with us, but it has stopped long enough for everyone who has any opinion on the subject to find opportunities for expressing it. There has been much discussion and some hard hitting, but latterly even the strongest opponents of the new comer have shown a disposition to cultivate his acquaintance; but the controversy is by no means dead, for on the one hand we find Dr. Louis Bell reading a paper in connection with the Columbia College University Extension, in which he claims for the alternate current system "almost unlimited power over the voltage, which we want for various purposes, greater than we could ever have with the direct current even at its best," and finally says concerning the present wofully low efficiency of the glow lamp (5 per cent.), and the possibility of improving it, "I would venture to predict that the alternating current will be, if not the immediate, at least the most potent, agency in the hands of the discoverer," whilst on the other hand we have Sir David Salomons, who sums up the advantages of the alternating current as "Nothing more than lower capital cost of copper." We did not invent the alternate current and we have no pecuniary interest in its advancement, but we have always believed that it possessed some other important features, not the least of them being that it will drive a revolving armature, which a continuous current will not do without a commutator. Sir David in his further remarks on the alternate current debits it with the production of continual vibration in armature coils, and he fully explained his exact meaning, in a letter which we published last week, by quoting his experiments, with a lamp filament in a steady field, at the Royal Institution. We are not surprised that under the conditions of the experiment there was strong and visible vibration. Our correspondent, "T. R. K.," approaching the subject from another point of view, credits us with having said "that the vibration in alternator coils is only imaginary," which we did not say. On the contrary we said: "Dynamos, continuous or alternating, can easily be designed so that the stresses are not only varied but also partially reversed; in such cases the vibration which is or may be set up should be attributed to the designer, and not to the alternate current." The particular case quoted by "T. R. K." has only a very remote and academic bearing on the subject. Dr. Thompson says, p. 638: "It is clear that if there is little lag there will be little motor action." He also explains how the tendency of capacity is to cause the current to lead, so that skilful designing can in this case eliminate those effects which Sir David debits to the current which alternates. As a matter of fact, the alternators which light the City of London and have air cores, belong to a class which is particularly free from self-induction troubles; the City transformers also being banked, are necessarily always under load, with the result that the effect of lag which Dr. Thompson treats hypothetically, and which "T. R. K." inquires about, is nearly, if not quite, negligible. The racking strains and the vibration particularly referred to by Sir David Salomons can be produced in almost any form of continuous current dynamo by a little careful inattention to the first principles of design.

THE BRITISH ASSOCIATION.

STORAGE BATTERIES.

By H. A. Earle.

(*Read in Section G, on Monday, September 16th, 1895.*)

When I undertook to read a paper before this Association, I hoped that I might have been able to treat the subject in a more exhaustive manner; the time at my disposal has, however, been limited, and the subject is one of such magnitude, and the results under different conditions of test so numerous, that I have found it impossible to do more than give a general outline from a practical point of view.

It is interesting to trace the history of storage battery manufacture, and, by so doing, each step in the advance up to the present time can best be considered.

The discovery of secondary currents dates back to 1801, when Gautherot found that silver or platinum wires, which had been used to decompose a saline solution, were capable of giving a reverse current of short duration. Ritter, in 1803, was, however, the first to make a secondary battery, in which he employed plates of gold separated by cloth or paper, the same being moistened with a saline solution; he experimented with various metals, including lead, but the secondary currents obtained were of short duration, and the batteries only of scientific interest. It appears, at first sight, strange that Ritter, when using lead, obtained no increased effects, this being the metal exclusively employed at this time; he, however, used salt water, and this formed chloride of lead which is scarcely soluble, and is a very bad conductor; on this account the current was very weak in comparison with that which would have been obtained if water, acidulated with sulphuric acid, had been used.

Since that time, many scientists have investigated the subject, and de la Rive, in 1826, obtained secondary currents from platinum plates in a voltameter filled with water and sulphuric acid, and he closely approached the elements of our present storage battery, when, among his many experiments he used in a primary battery a platinum plate covered with a film of peroxide of lead, and a zinc plate, immersed in an acid solution.

The first powerful storage battery was introduced in 1860, when Planté constructed cells composed of lead plates immersed in an acid solution of 1·068 specific gravity (10 per cent. acid); these were a success, with the exception that the method employed for their formation, namely, frequent charges, discharges, reversals of charge, and periods of rest, was too long and expensive for practical purposes, several months being necessary to obtain a useful capacity.

The subsequent rapid development and improvements in electrical machinery and lamps created a real demand for a good storage battery, and turned the thoughts of many to the subject, and the next, and one of the most important of subsequent improvements, was that introduced by Faure, in 1881, namely, of pasting a coating of lead oxide on the surface of the plates, which rendered them, after a comparatively short formation, ready for use. The Faure cell was never, however, as originally designed, a practical success, for though the active material was encased in a covering of flannel or felt, the pasted coatings being on upright surfaces, and having insufficient adherence, came away within a period not sufficiently long to give economical results. Swan realised that the active material required a better mechanical support, and introduced a plate of grid form, the interstices serving to retain the material; this frame, combined with the Faure pasting, was the origin of the plate that has been largely used in this country and elsewhere.

Up to the date of the expiration of the Swan and Faure patents, the manufacture of pasted plates in this country was in the hands of one company and its licensees, and competition was thereby to a great extent absent; this is, however, more likely to have been an advantage than otherwise, for much has meanwhile been done to perfect and cheapen the production of the solid lead plates, and these are making such strides forward that it seems probable they will eventually outstrip and replace their pasted rivals; solid plates have been made of various types, and some have been pasted to avoid the expense of formation, the paste in this case serving to give the required capacity till the action of charging and discharging gradually attacked the solid surface; improved methods, have, however, been discovered for effecting rapid formation at a reasonable cost, and although pasting is now open to all, in all probability there will be little extension of its use, unless means are devised for the better retention of the material.

Another type which differs greatly from the solid lead plate, but which is not pasted, is the chloride plate; in this case the material, to become active, is a mixture of chloride of lead and chloride of zinc, which is cast into small tablets, these being framed by casting antimonious lead around them under high pressure, the subsequent elimination of the chlorine and zinc leaving a porous structure of pure lead, of a crystalline nature, good conductivity, and with a large surface exposed to the electrolyte, the result being a large capacity for a given weight and for the space occupied.

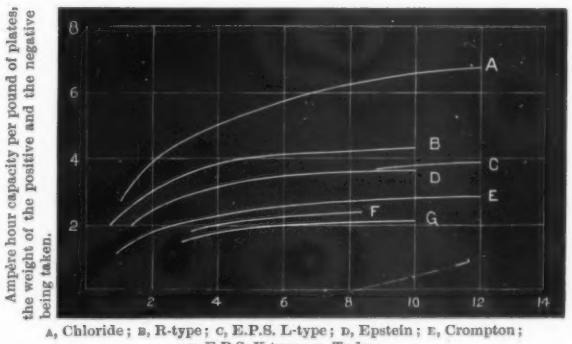
The mere manufacture of an accumulator, with lead and sulphuric acid, is a simple matter; but when combined with the necessary requirements of low first cost for a given capacity, and long life, it presents more difficulties than is perhaps generally supposed. Omitting the question of cost, the chief points to be considered are the *chemical action*, the *mechanical construction*, and the proper *treatment* of the cells when made. In lead batteries the minimum weight is limited by the chemical requirements, the theoretical value of lead peroxide is 4·44 grammes per ampère-hour, or roughly, 1 lb. is the equivalent of 100 ampère-hours; presuming that the positive and negative plates were identical, the value would be approximately 50 ampère-hours for 1 lb. of peroxide and spongy lead. As a matter of fact, the highest capacity plates yield only about 7 ampère-hours per pound of positive and negative plates, or 16 ampère-hours per pound of peroxide and spongy lead, due to the facts that a conducting frame of considerable weight has to be employed, and to the impossibility in practical working of reducing the whole of the peroxide. To obtain the best results for a given weight, the frame must be reduced to a minimum consistent with the necessary strength and conductivity, and the distribution of the peroxide must be such as to admit of the perfect circulation of the electrolyte, and its penetration throughout the mass.

When the active material is retained in holes or interstices, due provision must be made for its expansion on oxidation, for the power exerted is so great, that it will bend or burst a frame which holds it too tightly; various methods have been adopted to prevent buckling, but it is still a source of trouble with perforated pasted plates; solid grooved or ribbed plates, however, the grooves on which are filled with paste, are not subject to the same extent to this fault; solid plates on which the active material is formed out of the substance of the plate itself are practically free from it.

In the chloride plate ample provision is made for this increase in volume by the elimination of the chlorine and zinc, which renders the structure porous and cellular.

Nothing is more interesting than the behaviour of cells under various conditions, and from the innumerable curves that can be plotted, we can readily study the effects due to different rates of charge and discharge; to the penetration and strength of the electrolyte, and to the ratio of the positive and negative plates, from these and many other similar tests, much useful information can be obtained for guidance both in manufacture and treatment. There is a given rate of charge for every type of cell which is most suitable, not only for its efficiency, but also for its durability; with some types a high rate is quite inadmissible, and a period of 10 hours is required; other types, however, are of such a construction, that they may be fully charged in four hours without detriment; this variation is mainly due to the disposition of the active material, to its thickness, and to the method of its production, namely, whether it has been mechanically applied, or electrolytically produced. Most of the effects of varying rates of charge can be ascertained from the resultant discharge, but discharge curves have, nevertheless, characteristics of their own which are, to a great extent, unconnected with the conditions of charge, and they depend upon the type of plate, strength of acid, the rate of discharge, and other influences.

A series of curves is exhibited (fig. 1), and these give at a glance results obtained with plates of various manufacture. In every instance the weight of one positive and one negative has been taken; knowledge of the ratio of weight of active material to frame is natu-



A, Chloride; B, R-type; C, E.P.S. L-type; D, Epstein; E, Crompton; F, E.P.S. K-type; G, Tudor.

Duration of discharge in hours.

Fig. 1.

rally necessary for the complete investigation of these curves, but in this case the weight of the plates themselves has only been taken into consideration, as it is nearly intended to show results obtained from various types of plates at present manufactured.

Curve A is taken from plates, the active material on which is of a very porous and cellular nature, of $\frac{1}{16}$ths of an inch thick. It will be noticed that the capacity per pound of plate continues to rise up to the 12-hour rate, and that at that point is still slightly on the increase. This increase is no doubt partly due to the gradual penetration of the acid, and partly to the rapid sulphation of the surface at the higher rates.

Curve B is that given by a positive plate, the active material on which is distributed in a thin layer over a very large surface, the negatives being the same as employed for curve A. This plate gives less ampère-hours per pound of plate, owing to its possessing a heavy frame, but per pound of peroxide of lead its yield is greater; the active material in this plate is not formed out of the substance of the frame, but is entirely independent of it. A plate of this description, in which the whole face of the active material is directly exposed to the electrolyte, is capable of giving its maximum capacity at a comparatively high rate of discharge. A thin layer of peroxide spread over a large surface reduces the clogging of the surfaces to a minimum, and a free circulation of the electrolyte admits of fresh acid of the proper specific gravity being continually available.

Curve C is obtained from a pasted plate suitable for slow rates of discharge, and from its rise in capacity at reduced rates we notice somewhat similar characteristics to that in curve A.

There is, however, a remarkable point of difference between curves A and C, for the plates in each instance contain approximately 30 per cent. by weight of active material; curve A, therefore, gives us about double the ampère hour yield per pound of active material over curve

C, and this is obtained by the cellular and porous structure of the material in the A curve plate.

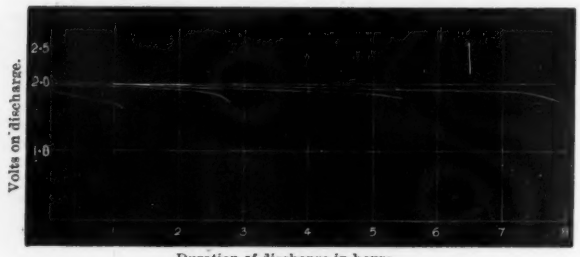
Curve D is taken from plates cast with ribs on their surfaces, the active material being formed out of the substance of the plates themselves, the curve is very similar to B, but falls lower on the scale, this being caused by the weight of the positive plate, its thickness being considerable in order to give a reserve of metal, which in its turn is acted upon as the plate gradually disintegrates.

Curve E is given by plates, the surfaces and interior being full of blowholes, which gives a large exposed area; their weight for a given output is, however, large.

Curve F is a pasted plate with a solid frame, which gives a poor return for its weight; in this curve we notice the rise in capacity at reduced rates due to pasted plates.

Curve G gives the capabilities of very heavy plates which are pasted on their surfaces, the paste being intended merely to give the required capacity till its disintegration, by which time the frame itself has been sufficiently formed to do the work; the rapid flattening of this curve indicates that the layer of paste is thin.

The curve of voltage of a discharging cell varies greatly, and is dependent upon the rate of discharge, the strength of acid, the distance of plates apart, its curve of internal resistance, and the treatment it has been subjected to beforehand, besides many other interesting conditions.



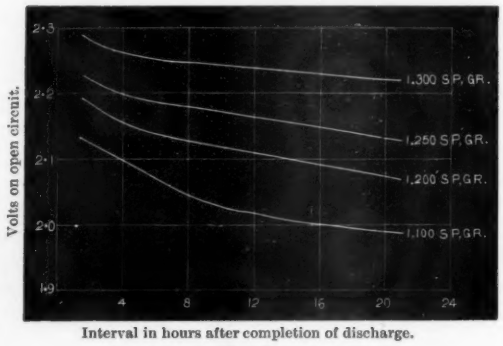
Duration of discharge in hours.

FIG. 2.

Fig. 2 demonstrates the effect of varying rates; these curves have all been obtained from cells of the same type, the acid having been approximately 1,210 specific gravity when the cell was fully charged.

Discharges at varying rates are given, namely, 1 hour, 2½, 3½, 5½, and 7½ hours, and though slightly different results would be obtained with other types of cells, they may be taken as a fair approximation for general reference.

When considering the question of fall in volts on discharges at different rates, it will not be out of place to draw attention to conditions that are frequently given in specifications for storage batteries—in some instances a fall in volts not exceeding 8 per cent., 10 per cent., or 12 per cent., is allowed, and the rate in ampères, and the time in hours, for which the discharge is to be maintained are stated. This is in most instances unsatisfactory, for what are we to take at our starting point? The E.M.F. on open circuit immediately after complete charge is practically a fixed value, with a given type of cell and a known strength of acid. But the fall in the first few minutes varies greatly according to the rates of discharge, and at high rates it may fall as much as 10 per cent. in a few minutes or even seconds, before a comparatively straight line has been reached, and the cell is working at its normal voltage for the specified rate of discharge; this is quite clear by reference to fig. 2. Another point to which our attention is drawn is the fall of voltage on open circuit after the completion of charge. A series of curves (fig. 3) are exhibited, showing the fall in voltage for a period of 21 hours, each curve being for a different strength of acid; it is therefore evident that if a given percentage of fall is allowed, it will be most advantageous for the manufacturer, but not for the purchaser, to allow the battery to stand for a few hours in order that this useless high voltage be reduced. The best way to meet this point is, however, to take the first reading of voltage five or 10 minutes after the discharge has commenced. In other specifications the voltage is fixed to a hundredth of a volt, and the cell must give the specified capacity above this limit in many instances, and especially when high discharge rates are specified, the voltage given is much too high on the curve, and in some instances I have found it actually fall on a straight portion of the same, so that the time at which this point is passed raises an unpleasant difference of opinion between the buyer and the seller; this class of specification generally necessitates a very much larger battery than was intended, with corresponding increased cost, and should the manufacturer not have been exceedingly careful in preparing his estimate, he may find that the buyer is not satisfied with a good excess of ampère-hours, but will have his volts as well, even if this means 50 per cent. in ampère hours in excess of what he thought he was ordering.



Interval in hours after completion of discharge.

FIG. 3.

There are many ways in which a specification can be framed so that a battery of the exact size required is obtained, and there is no doubt that it is most satisfactory to all concerned if the exact capacity in ampère hours is specified, and the final voltage of the complete battery at a given rate, the number of cells being omitted. Under these conditions, if the individual cells are discharged down to a low voltage, more cells would be required, but each additional cell on a 100 volt circuit adds 2 per cent. to their number, and correspondingly increases the cost of a battery composed of cells of a given size. On the other hand a low voltage per cell on discharge enables—up to a given limit—the number of plates per cell to be reduced, and the cost of cell as well. In a competitive tender the manufacturer would therefore work out the cheapest arrangement, and I find that this would not admit of the individual cells being discharged to too low a voltage, and that the purchaser would obtain exactly what he required at the lowest price.

The actual number of regulator cells is of small moment to the user, and the additional number required, when the individual cells are discharged down to a voltage of 1·8, in place of, say, 1·9, is only two in a 100-volt battery.

Charge.						Discharge.							
Charge No.	Duration of charge.	Rate in ampères.	Volts at end of charge.	Ampère hours.	Watt hours.	Discharge No.	Duration of discharge.	Rate in ampères.	Volts at end of discharge.	Ampère hours.	Watt hours.	Percentage of efficiency.	
												Ampère hours.	Watt hours.
	Hrs. Min.						Hrs. Min.						
1	3 00	15	2·68	45	...	1	7 30	15	1·68	113	218	...	...
2	9 45	"	2·68	146	...	2	7 45	"	1·70	116	227	79·4	...
3	12 00	"	2·68	180	428	3	9 25	"	1·70	141	278	78·3	64·9
4	12 30	"	2·67	187	443	4	9 50	"	1·70	148	285	79·1	64·3
5	8 45	"	2·50	131	299	5	8 40	"	1·70	130	255	99·2	85·3
6	11 15	"	2·40	169	399	6	9 35	"	1·91	144	274	85·2	68·7
7	11 15	"	2·38	169	398	7	9 32	"	1·915	143	276	85·2	69 3
8	10 35	"	2·136	159	324	8	9 15	"	1·90	139	273	87·4	84·2
9	10 35	"	2·333	159	375	9	9 10	"	1 90	138	264	87·4	70·4
10	10 15	"	2·333	154	361	10	9 00	"	1·90	135	265	87·6	73·4

When tests are made to check the efficiency and capacity of a battery, we can place no reliance on the figures obtained from a single charge or discharge. As a rule, no two consecutive discharges from a cell are identical, even when the same is discharged with the same current, and down to the same voltage; every discharge being greatly influenced by the previous treatment The above table clearly demonstrates this.

This table is in no way intended to be a guide as to what can be obtained in efficiency tests, but is merely to show the irregular nature of results obtained with slight variations in time and maximum voltage of charges; the rated capacity of the cell was 15 ampères for 10 hours, or 150 ampère hours.

Charge No. 1 we can omit, as this was given to complete the formotion of the cell.

Charge No. 2 was for a similar purpose.

Charge No. 3 was continued, as were also charges 1 and 2 till the voltage had practically ceased to rise; a high voltage on charge gives a good return in ampère hours on the discharge, but if a cell is

forced to its maximum capacity we obtain a poor return in efficiency.

Charge and discharge No. 4 are very similar to No. 3.

Charge No. 5 was stopped when the E.M.F. had risen to 2·5 volts and 30 per cent. less ampère hours had passed through the cell. Studying the figures up to the end of charge 5, it would have been practically impossible to assume what was going to happen on discharge No. 5; on taking this discharge, we obtain 20 per cent. increase both in ampère hour and watt hour efficiency, and the very high percentage of the former, namely, 99·2 per cent., points to the fact that peroxide, which had been previously inactive, was reduced. The first five discharges you will note were all taken down to 1·70 volts; this cell had never been used before, so we have its history up to the 10th discharge in the table—the strength of acid at end of charge was practically 1·300 specific in every instance.

Charge No. 6 was only continued to 2·40 volts, but it required 2½ hours longer charge to reach this voltage than it previously did on charge 5 to reach 2·5 volts, and this was, without doubt, due to the good service rendered on the last discharge.

The remaining charges and discharges show that the highest efficiencies are obtained when the cell is not charged up to a high voltage, and if worked within reasonable limits, 90 per cent. in ampère hours, and about 80 per cent. in watt hours, can be obtained with the cell in question when in good order.

Usually efficiency is not of great importance, for, presuming a central station battery to give one-tenth of the total supply, a variation of even 10 per cent. in efficiency would only represent 1 per cent. variation in the total output; but the time may come when batteries are so cheapened and perfected, that they supply the whole demand of our station, and their efficiency will then be one of importance, and we may be confronted with specifications as strict as those now framed for dynamos.

The strength of acid solution to be used in a cell is an important point. In the first place, this greatly influences the voltage, as we have seen from fig. 3; it has also a great effect upon the life; besides this, in strong acid the plates sulphate more readily, and the sulphate is more difficult to reduce; it is therefore necessary to carry out most careful tests to ascertain what strength of acid should be used in each type of cell.

The resistance of acid solutions of different strengths is also a most important consideration, and on fig. 4, four curves are shown giving its resistance at 0°, 8°, 16°, and 24° Centigrade. Taking 16° Centigrade as a mean working temperature, it will be noted that

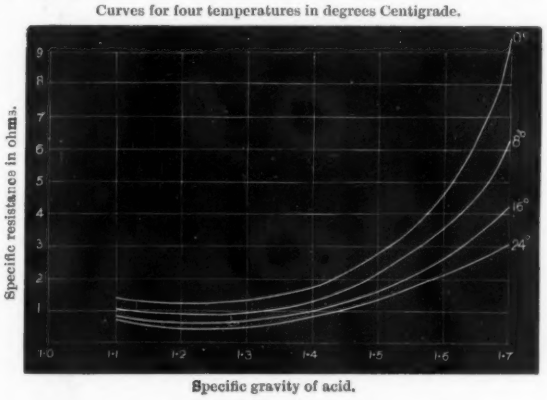


Fig. 4.

acid of about 1 250 specific gravity has the least resistance, and it might be assumed, therefore, that this was the best strength to work at, but we must bear in mind that this strength does not give us the hightest voltage; and, moreover, the gravity gradually falls as the cell discharges, and when working with this strength we have falling voltage on discharge, and at the same time increasing resistance of the electrolyte; no fixed law can be laid down, as each type of cell requires a given strength for best results.

Immediately upon commencing our research with a view to ascertain the proper strength of acid, we find that we are confronted with another problem of great interest, which is, that different strengths give us different capacities from our cell. Fig. 5 gives two most interesting and instructive curves taken from two cells of the chloride type, one with positive and negative plates of ·24 of an inch thick, curve A, and one with positive and negative plates of ·4 of an inch thick, curve B. Each cell was discharged at a rate equal to ·45 of an ampère per pound of plate. The rate per pound of active material is nearly the same for each cell, though perhaps slightly higher for the thinner plates. The rate of discharge per superficial area was, therefore, approximately 40 per cent. greater with the thick plates than with the thin.

The curves give the yield in ampère hours per pound of active material with different strengths of acid. Considering the thin plate curve first, we find that with acid of 1·070 we do not obtain more than about 3 per cent. of the maximum capacity from this point to 1·230, at which point we obtain the maximum capacity, it rises very rapidly; each addition of 1 per cent. to the sulphuric acid present in the electrolyte, giving an increase of about 1 ampère hour capacity per pound of peroxide; from 1 230 to 1·500 it falls as rapidly almost as it rose, and at the latter figure we obtain only 16 per cent. of the maximum.

Taking the thick plate curve: At 1·040 specific gravity we obtain about 6 per cent. of the maximum capacity, and it rises till 1·270 is reached; it then falls rapidly, and at 1·500 the output is practically *nil*.

Considering these two curves, we note that the thin plates give as a maximum,

15 ampère hours per pound of peroxide and spongy lead, or

30 ampère hours per pound of peroxide alone, or about one-third of the theoretical value.

The thick plates on the other hand give

10 ampère hours per pound of peroxide and spongy lead, or

20 ampère hours per pound of peroxide alone, or about one-fifth of the theoretical value.

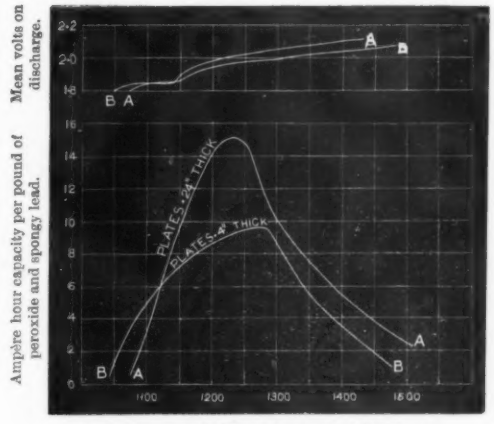


Fig. 5.

The natural question is, why is this the case? Also, why are the thick plates the best with very weak acid? and why do they give such a much poorer return with acid of the strength usually employed? I consider that up to the point at which the curves cross, the better result obtained from the thick plates is due to the fact that on completion of the charge in weak acid, the active material is saturated with strong acid, and the quantity contained in the same would be greater with the thick plates than with the thin, and they would therefore give a better output with weak acid than the thin plates. Their increased thickness, however, is of no advantage with acid of the ordinary strength; when out capacity is chiefly dependent upon the penetration of the acid, if we study the portion of the thick plate curve between 1·150 and 1·400 specific gravity, and compare it with the thin plate curve, we find that the capacity is practically reduced inversely as the thickness or weight of the plate, and the rate of discharge of the superficial area. Quite apart from the question of the proper thickness of the active material, we can see at a glance that very different capacities are obtained with different strengths of acid.

On the top of the same figure the mean volts during the discharge are given; these, it will be seen, rise steadily as the strength of the acid is increased; a striking feature is that the curves of voltage cross at the same point that the curves of capacity cross; upon consideration we come to the conclusion that this is what would be expected, as the rate in ampères on discharge was the same in every case, and an increase in ampère hours per pound of material means a longer time to complete the discharge, and we see from fig. 2 that the greater the length of the discharge, the higher the mean voltage.

It is the manufacturer's business to make as good a cell as possible, but when it leaves his hands, it is judged by the service it renders during its life; this depends to a very great extent upon the treatment it receives. In the first instance purity of the electrolyte is essential; brimstone acid should be used, as this is the least likely to contain foreign substances; if this is diluted on the spot, the water must be pure, preferably rain, or, if possible condensed, water.

With regard to the first charge of the battery, it is generally imperatively stated that this must commence immediately upon the acid being put into the cells; this is no doubt necessary with imperfectly formed pasted plates, or with plates which have been for some time exposed to the air, as they would readily sulphate, and require a considerable time to reduce; but positive plates which have been fully formed, and negatives in good condition, are very slightly affected.

Fig. 6 gives five curves, which I have prepared in order to show results obtained from plates in different conditions, some having been left standing in the acid, while others were charged.

Curve A shows the specific gravity of the acid in the cell, in which the plates were allowed to stand for 22½ hours without being charged. During this period it remained absolutely constant, sulphation was therefore absent; the charge was then commenced and continued for eight hours, a rise in specific gravity took place, raising the electrolyte to a gravity above that at which it was put into the cell, which showed that sulphate was previously present in the plates.

Curve B shows what happened in another identical cell; directly the charging current was started the gravity fell rapidly. This, I presume, is due to the formation of oxide of lead from the pure lead remaining in the active material, and this is sulphated before becoming peroxide of lead. The current throughout the charge was kept constant, and from the curve we see that practically the same number of ampère hours were expended during the fall as during the rise; the specific gravity in this instance also rose slightly above its initial value.

The plates in curve C, which had been standing, sulphated slightly, and reproduced, on being charged, to a small extent a similar curve to B, and the plates (curve D) which were charged at once give a very small fall, but a considerable rise, showing that sulphate was present in the plates.

Curve E is for plates which stood before being charged, and in this instance we notice that no sulphation took place, and that they gave a small fall and rise.

My chief object in giving these curves is to demonstrate how very slight differences can give considerable variations.

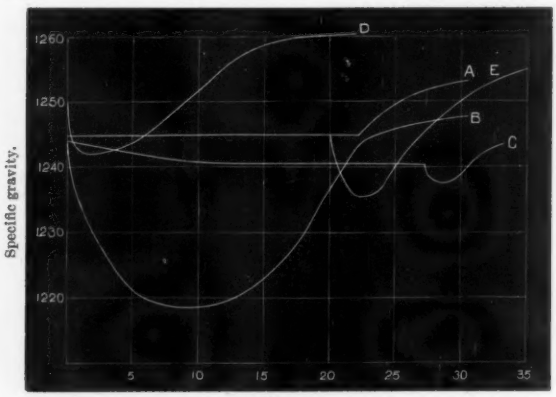


Fig. 6.

To return again to the treatment of cells, the chief causes of destruction are too prolonged, or excessive rates of discharge, insufficient charging, overcharging, long periods of rest on open circuit without charging, and allowing cells to remain after complete discharge for many hours before recharging. There is also another point which is worth mentioning. Frequently through undercharge or over-discharge the plates become heavily sulphated, the cells no longer give their proper output, and the specific gravity of the electrolyte falls considerably; of course, a prolonged charge will put this right, but frequently it is assumed that, as the specific gravity is low, the acid merely requires strengthening, and this is done with the best intentions; the fault is, however, aggravated, and the plates sulphate more heavily than before; I found on one occasion that acid had been periodically added, and the specific gravity rigidly maintained at 1,200, the charge being always stopped when this strength was reached; the cells were naturally working badly; a prolonged charge was accordingly given, and this raised the strength of the electrolyte as high as 1·450 in some cells, which was a clear indication of what had been done. We find, therefore, that a multitude of causes influence the working and life of storage batteries, and that many of these can be varied at will; the problem, therefore, is to so combine all useful effects, that we produce the best possible article with due consideration to low cost.

It would be a natural question to ask, What do you consider the best possible article? and this is easily answered. In a secondary battery we have lead, sulphuric acid solution, and the resultant compounds, and nothing else.

The ideal cell is one that is indestructible, and this being given, the first cost and weight, if kept within reasonable limits, are of little moment.

At the present moment the life of a cell is its value, and all types are constructed with the knowledge of certain death, and in most types this lingering death is provided for, for we find at the bottom of the boxes a sufficient space to act as a receptacle for the deposit from the disintegrating plates; in other types, where the active material is held permanently in position disintegration still goes on, with consequent loss of contact. Now this integration is what we have to stop; the deposited disintegrated material is as good as ever, for nothing is wasted, and provided it were held in perpetual, firm, and good electrical contact with the frame, in such a manner that the free circulation and penetration of the acid were not hindered, and the internal resistance were not unduly increased, we should have produced an ideal and indestructible cell.

I have brought to your notice only a very few of the many interesting features in connection with secondary batteries, and these only in a most superficial manner. I have, however, endeavoured to give a general outline of results obtained in practice, and have not entered into a discussion upon other more serious questions. Many conjectures arise in one's mind when considering the causes of different effects, and each point requires much time and study in order that a fixed law may be deduced from the results obtained, and again the results of tests are often so conflicting, and depend so much upon very small differences of condition, that it is by no means an easy matter to arrive at the truth.

AN IMPROVED PORTABLE PHOTOMETER.

By W. H. Preece, C.B., F.R.S., and A. P. Trotter, B.A., A.M.I.C.E

(*Read in Section G, Monday, September 16th*, 1895.)

When light falls upon a surface, that surface is said to be illuminated. The illumination depends simply upon the light falling upon the surface, and has nothing to do with the reflecting power of the surface, just as rainfall is independent of the nature of the soil. As a rain gauge receives the full amount of rain when it is placed horizontally (disregarding wind), and receives less when it is tilted, so a surface is fully illuminated when it faces the source of light, and is less fully illuminated when the light falls upon it at an angle. The proportion between the full rainfall or illumination, and the measured rainfall or illumination, varies as the cosine of the angle of incidence of the rain or of the light. This angle is 0° and the cosine is 1, when the rain gauge is placed horizontally, or when the light falls perpendicularly upon the surface.

It would perhaps be unnecessary to call attention to these very elementary matters, were it not that difference between the photometry of illumination, and the ordinary photometry of candle-power, is often confused.

The lighting of streets and of buildings may be specified by the maximum and minimum illumination. The primary purpose of an illumination photometer is to measure the resulting illumination produced by any arrangement of lamps, irrespective of their number, their height, or of their candle-power. Illumination photometers containing sub-standards of light have been designed by Prof. Weber,* Prof. Mascart,† and others. One of us described an illumination photometer before the Royal Society in 1883.‡ This consisted of a box blackened within. Over the end was stretched a Bunsen screen of paper, on the middle of which was a grease spot. At a distance of 12 inches was another screen, of drawing paper. The grease spot was so screened that no light fell upon it, except that which was reflected from the drawing paper screen. At the end of the box opposite the Bunsen screen was an eyepiece, consisting of a plain tube, within the box a small glow lamp was fixed, and in order to make a measurement of the illumination of the drawing paper screen, the current through the lamp was varied through a rheostat until the grease spot was invisible. The readings were recorded in luces, a lux being suggested by one of us at the Paris Electrical Congress, 1889,§

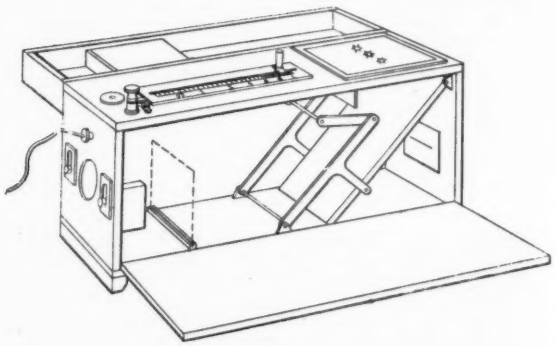


Fig. 1.

as the name for the illumination due to a carcel lamp at 1 metre, and equivalent to a British standard candle at 1·058 foot. The only defect of this photometer was the yellowish and reddish colour of the lamp when dimmed for low readings.

In 1884 we designed a portable photometer,‖ in which the lamp could be moved towards, or withdrawn from the Bunsen screen, and a mechanism was provided by which, when a pointer moved a certain distance over a uniformly divided scale, the displacement of the lamp was as the square of that distance. The Bunsen spot was viewed by Rudorff mirrors, in the usual way. This instrument worked well, but the range was small, and could not be easily increased. The lamp would have to be moved to a very considerable distance from the screen, for measuring the feeble illuminations met with in street lighting.

Eight years later, one of us experimented with modifications of this instrument, and found that in ordinary street lighting the illumination is often only equal to that due to one candle at 14 feet distance. A large number of different methods of reducing the light were tried. Many combinations of lenses, the eclipsing device used in dissolving views, photographically shaded glass screens, and other devices were used, and, finally, a white reflecting screen was inclined at different angles to a small electric lamp, and on this principle a photometer was constructed in February, 1892. It was found that the Bunsen screen could be replaced with advantage by a simple white cardboard diaphragm pierced with one or more holes.¶ The illumination of this diaphragm, generally in a horizontal position, was the illumination to be measured. Below this was the reflecting screen, enclosed in a box about 2 feet × 6 inches × 5 inches, with a pair of small glow lamps and a secondary battery. The screen could be inclined towards the glow lamps by means of a chain wound up on a cam mounted on a spindle, the cam being formed so as to give an open scale. A hand or pointer indicated readings on a dial. Many measurements and a number of photometrical surveys of different streets and public buildings in London were made in 1892, and are recorded by means of plans with isophotal countour-lines and otherwise.**

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* *Electrotechnische Zeitschrift*, 1884, p. 166. *La Lumière Electrique*, Vol. xii., p. 468.

† *Bulletin* de la Soc. Inst. des Electriciens, 1888, p. 103.

‡ *Proceedings* Royal Society, xxxv., p. 39, 1883, and *Proceedings* Inst. C.E., Vol. cx., p. 98.

§ The *Electrician*, Vol. xxiii., p. 478.

‖ *Proceedings* Inst. C.E., Vol. cx,, p. 101.

¶ *Proceedings* Phys. Soc., xii., p. 355, 1893.

** *Proceedings* Inst. C.E., Vol. cx., pp. 42—51.

During the present year an improved form of this photometer has been constructed. The chain and cam, which allowed the instrument to be used only in a horizontal position, have been replaced by a system of levers. The object of these levers is to give an open scale. If the motion of the pointer were proportional to the angular movement of the screen, the scale would be approximately a scale of cosines. The instrument is shown in fig. 1, with the lid open, and the front let down. It measures 1 foot 3⅜ inches by 5½ inches by 9½ inches high (400 mm. × 140 mm. × 242 mm.). On the end to the left there is a red glass window, and immediately within are two 12-volt lamps (one of which is shown in fig. 2), one of about 1 candle-power, and the other of 2 candle-power. It can be seen through the window if either or both of the lamps are alight. The lamps are held in special lamp-holders, capable of adjustment as to height by clamping screws. These clamping screws and the base of one of the lamp-holders are shown in fig. 1. A switch on the top of the instrument enables either or both of the lamps to be turned on or off. At the other end of the box the reflecting screen is hung. The middle of the screen is about 11 inches (28 cm.) from the lamps. It is shown in fig. 1 in its lowest position. In fig. 2 the screen and one of the levers, together with one of the rollers on which the screen rests, and the handle by which it is moved, are shown with the screen in its highest position by full lines, and in its lowest position by dotted lines. In its highest position the filaments of the lamps are a little below the plane of the screen, no direct light from the lamps then reaches the screen, and it is only faintly illuminated to about $\frac{1}{200}$th of one candle at a foot, by stray light, which is excluded as much as possible.

The diaphragm is placed horizontally immediately above the hinged screen. Three small star-shaped holes are cut in and through them, the illuminated reflecting screen can be seen. A handle carrying a pointer, moving over a graduated scale, controls the inclination of the screen by means of the levers and links. A guide attached to the back of the screen (shown in fig. 2) allows the instrument to be turned

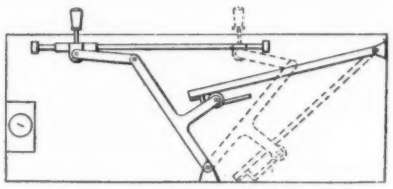


Fig. 2.

on its side without interfering with the working. In order to take a measurement, one or both of the lamps are turned on, and the handle is moved until the screen seen through the holes in the diaphragm matches the diaphragm in brightness. If the colour of the light outside is about the same as that of the lamps, the middle hole may be made to disappear. The observer should stand approximately in the vertical plane passing through the three holes, so that he may see that part of the screen through them which lies immediately beneath them.

Various substances have been tried for the diaphragm and screen. Thin metal painted with a whitewash made of magnesia and isinglass is perhaps the best. The diffused reflection practically follows Lambert's cosine law, but the material is easily soiled and cannot be cleaned. Bristol board from which the glaze has been removed by a damp cloth, closely follows the cosine law within the angular range required in this case. It is important that there should be no glaze on the surface of the hinged screen, since the inclination of the lamp to the screen, and of the screen to the eye for maximum illumination, is about 45°. But as the scale is graduated by experiment, a slight departure from the cosine law does not matter. On the other hand, it is of greater importance that the screen should be very smooth and flat. Under very feeble illuminations the light from the small lamp, making an angle of incidence very nearly 90°, minute irregularities are easily seen, and make accurate readings difficult. For ordinary street lighting and for general industrial photometry, a slight departure from the cosine law on the part of the diaphragm is of no practical consequence, so long as there is no perceptible glaze, for it is always observed nearly vertically and never at a large angle.

The colour difficulty is reduced, in the first instance, by the freedom of motion of the levers. The handle may be quickly moved to and fro on each side of the true reading, and the middle position may be estimated. In measuring the illumination due to arc lamps, the colour difficulty becomes troublesome. The colour of the glow lamp in the photometer should be approximately a mean between the colour of the standard of light wherewith the instrument is calibrated, and that of an arc lamp. This halves the difficulty which can never be entirely removed, since differently coloured lights are not physically comparable; it may, however, be relegated entirely to the laboratory by the use of a coloured screen and diaphragm.

If the hinged screen be tinted pale blue, some of the yellow rays of the lamp in the photometer are absorbed, and the reflected rays approximate to grey, that is, to feebly illuminated white. On the other hand, if the diaphragm is tinted yellow, the white light from electric arcs or of daylight may be reduced to approximately the same colour as that of the lamp in the photometer. In the first case the brilliance of the hinged screen is reduced, and a brighter lamp would have to be used to restore the true value of the scale readings, and in the second case the brilliance of the diaphragm would be reduced, and the scale readings would be too high. But by tinting both screens, the calibration of the instrument need not be disturbed. The screen being coloured pale blue and the diaphragm pale yellow, there is no difficulty in obtaining disappearance of the hole in the diaphragm when illuminated by arc light, or even by daylight. The selection of the colours suitable for obtaining a true measurement is based upon the mean of a number of measurements. White screens are used, and the comparison should be made in a building illuminated with a number of arc lights. A number of measurements are made with quick oscillations of the handle, and the mean is taken. Several screens and diaphragms of different tints being in readiness, pairs are tried, and a selection is made of a pair which give a good colour match*, and, if possible, the mean reading given by the white screens. A slight departure from the mean could be corrected by the use of a coefficient. It is not suggested that strongly coloured lights can be scientifically compared in this manner, but only that the yellowish light of a glow lamp may be compared with the whitish light of an arc or of subdued daylight. We employed this device in 1884, and Messrs. G. W. and M. R. Patterson, the translators of Palaz's "Industrial Photometry," who have used it in connection with a Lummer-Brodhum photometer, remark † that "it can, of course, give no additional absolute accuracy to the photometric measurements; it, however, adds greatly to the comparative accuracy of the results, as it makes it possible to measure relative intensities under various conditions with great precision." But it should be observed that the selection of the tints may be made at leisure, and under favourable laboratory conditions, and by thus avoiding all colour trouble during ordinary use of the photometer, a very considerable gain in precision is secured.

Fig. 3.

The scale is 5½ inches (137 mm.) long, and is shown in fig. 3. With the smaller of the two lamps, the highest reading is equivalent to one candle at a foot, with the larger lamp it is twice this illumination. The oscillations of the handle generally extend, at first, over two scale divisions, and after three or four oscillations their amplitude may be reduced to about one scale division. The half of a scale division may be estimated except at the highest part of the scale, which is slightly contracted. The precision is about 2 or 3 per cent. The contraction of the upper part of the scale is intentional, and is caused by the arrangement of the levers.

In case of renewal of the lamps, it is very important that other lamps should be placed in exactly the same optical position in the photometer; otherwise the scale would have to be re-calibrated. In order to fix the height of the lamps, which is the only adjustment necessary, a sheet metal screen, shown by dotted lines in fig. 1, is placed in a holder attached to the floor of the photometer. Two small holes are drilled in this screen, and a white paper screen having a black horizontal line is fastened to the end of the box (see fig. 1) opposite to the lamps. The hinged screen being lifted by the levers out of the way, "pin hole images" of the filaments are thus thrown on to this screen, and the lamps being set (see fig. 2) so that the single horse-shoe filament appears nearly closed up, the dark line between its two limbs is made to fall on the black horizontal line. The images being magnified, considerable accuracy is possible.

Although the principal object of this photometer, as of those which preceded it, is the measurement of illumination, it is sometimes desirable to measure the candle-power of a lamp in the street without removing it from its position. By the use of a graduated arc, such measurements can be made with the present photometer. A quadrant is fastened to the side of the photometer, and a pin at the centre, from which the quadrant is struck, acts as a gnomon. A spirit level on the top of the instrument being adjusted, the angle of incidence may be read in degrees on the quadrant, and at the same time the cosine of this angle may be read on an adjacent scale. It is necessary to find the slant height or direct distance from the source of light to the photometer.

To measure the vertical height of the light, set the photometer so that the shadow falls on 45°. Measure the distance from the pin to the lamp horizontally, and from the pin to the ground vertically. The sum of these distances is the height of the actual source of light. This can be measured to about 2 per cent., say 3 inches in 12 feet 6 inches.

To find the slant height at any distance, the height of the light being known, divide the height of the lamp above the photometer by the cosine of the angle of incidence, the quotient is the slant height required; or the horizontal distance may be measured, and the square of this distance added to the square of the height of the light. This gives the square of the slant height.

To find the candle-power, the illumination in units of a candle at a foot being observed, the light from other lamps being carefully screened, the slant height being known. Multiply the illumination by the square of the slant height, and divide by the cosine of the angle of incidence.

On hilly ground it is necessary to know the height of the lamp above the photometer at each point of measurement. It is best, in that case, merely to record the angles, and afterwards to find the tangents. The horizontal distance between the photometer and the lamp-post, divided by the tangent, gives the required height.

It may be observed that when the square of the slant height in feet is equal to the cosine of the angle of incidence, the scale

* Owing to the Purkinje effect, an exact colour match cannot be maintained throughout the whole range. The holes in the diaphragm look yellowish under strong illumination and bluish under feeble illumination.

† "A Treatise on Photometry," Palaz, American translation, Appendix, p. 312.

graduated in units of a candle at a foot becomes a scale of candle-power, and when the square of the distance in feet is ten 100 or 1,000 times the cosine, the multipliers ten 100, or 1,000 may be used to convert it into a scale of candle-power. The square of the slant height being known, the photometer may be tilted until the required cosine is indicated by the shadow of the pin. If the slant height is measured by the sum of the squares of the horizontal distance and of the height, the square is at once obtained.

We have calibrated our photometers, either by standard candles or by sub-standard glow lamps supplied from secondary batteries, or by the amyl-acetate standard lamp or Hefner unit. This standard, which is well recognised in physical work, is 0·877 of a standard candle, or a standard candle is 14 per cent. more than an amyl-acetate lamp. Placed at 1 foot distance from, and perpendicular to the diaphragm, the photometer being placed on its side, the illumination is 0·877 of a candle at a foot. If it is brought to a distance of 11¼ inches ($\sqrt{0{\cdot}877}$ foot) it is equivalent to one candle at a foot. But this distance and position is inconvenient. If it is placed at a distance of 1 foot, and at an angle of incidence of 55° 10′, the illumination on the diaphragm is one-half of a candle at a foot, since cos. 55° 10′ = ·57 and ·57 × ·877 = ·5. A mark is therefore made at this angle on the quadrant, and is inscribed H.U. = ½ C.P. Considerable experience with the use of small glow lamps supplied from portable secondary batteries has given us great confidence in this kind of secondary standard of candle-power. The battery is always freshly charged before each evening's work, and is discharged for half an hour before use. The lamps are only turned on while an observation is being taken.

The 1883 photometer was arranged to be held in the hand; our 1884 photometer stood on a tripod about 2 feet 6 inches from the ground. The street measurements made in 1892 were all made with a photometer placed on the ground, the diaphragm being about

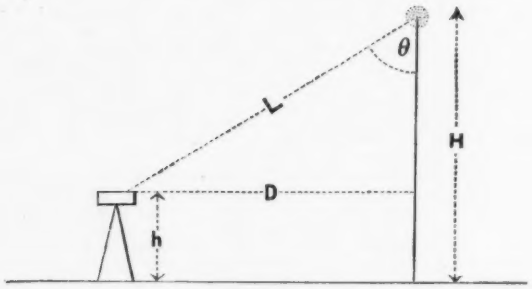


Fig. 4.

6 inches from the pavement. The proper height for an illumination photometer is a matter of opinion. When the photometer is placed on the ground, the large number of measurements required for a thorough photometric survey of a street or empty building can be quickly made. For some purposes, for example, an exhibition or a church, a stand is necessary; the calculations of candle-power become rather more tedious.

The various observed and computed quantities may be expressed as follows:—

D = horizontal distance from photometer to lamp-post.
L = slant height from photometer to light.
H = height of light above the ground.
h = height of the photometer diaphragm from the ground.
θ = angle of incidence.
cf^2 = illumination of units of a candle at a foot.
c.p. = candle-power.

$$H - h = D \div \tan \theta.$$
$$L = (H - h) \div \cos \theta.$$
$$= \sqrt{D^2 + (H - h)^2}.$$
$$c.p. = \frac{cf^2 \times L^2}{\cos \theta}$$

The following is an example of the measurement of the illumination and candle-power in the case of a street lamp:—

D	θ	cf^2	$\tan \theta$	$\cos \theta$	$H-h$	H	L	L^2	$cf^2 \times \cos \theta$	*c.p.*
20	66°	0·025	2·25	0·407	8·9	11·9	21·8	475	0·0614	29

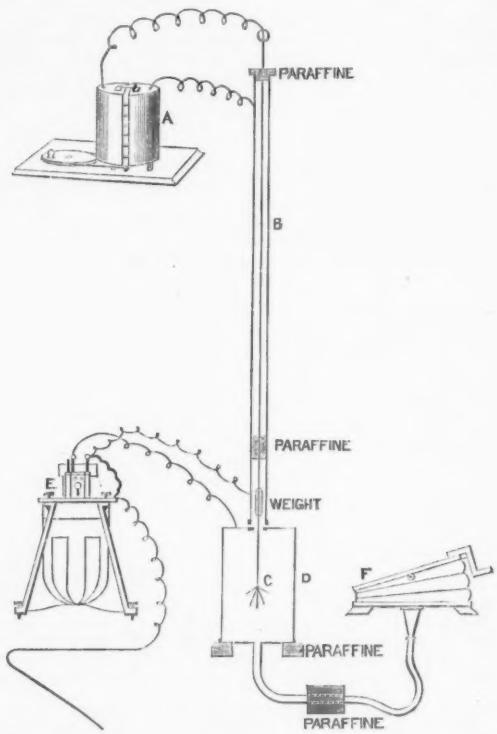
ELECTRIFICATION AND DISELECTRIFICATION OF AIR AND OTHER GASES.

By Lord Kelvin, Magnus Maclean, and Alexander Galt.

(*Abstract.—Communicated to Section A, September 17th*, 1895.)

§ 1. Experiments were made for the purpose of finding an approximation to the amount of electrification communicated to air by one or more electrified needle points. The apparatus consisted of a metallic can 48 cms. high and 21 cms. in diameter, supported by paraffine blocks, and connected to one pair of quadrants of a quadrant electrometer. It had a hole at the top to admit the electrifying wire, which was 5·31 metres long, hanging vertically within a metallic guard tube. This guard tube was always metallically connected to the other pair of quadrants of the electrometer and to its case, and to a metallic screen surrounding it. This prevented any external influences from sensibly affecting the electrometer, such as the working of the electric machine which stood on a shelf 5 metres above it.

§ 2. The experiment is conducted as follows:—One terminal of an electric machine is connected with the guard tube and the other with the electrifying wire which is let down so that the needle is in the centre of the can. The can is temporarily connected to the case of the electrometer. The electric machine is then worked for some minutes, so as to electrify the air in the can. As soon as the machine is stopped the electrifying wire is lifted clear out of the can. The can and the quadrants in metallic connection with it are disconnected from the case of the electrometer, and the electrified air is very rapidly drawn away from the can by a blowpipe bellows arranged to suck. This



Connected with guard screen (not shown in diagram).

Fig. 1.

releases the opposite kind of electricity from the inside of the can, and allows it to place itself in equilibrium on the outside of the can and on the insulated quadrants of the electrometer in metallic connection with it.

§ 3. We tried different lengths of time of electrification and different numbers of needles and tinsel, but we found that one needle and four minutes of electrification gave nearly maximum effect. The greatest deflection observed was 936 scale divisions. To find, from this reading, the electric density of the air in the can we took a metallic disc, of 2 cms. radius, attached to a long varnished glass rod, and placed it at a distance of 1·45 cm. from another and larger metallic disc. This small air condenser was charged from the electric light conductors in the laboratory to a difference of potential amounting to 100 volts. The insulated disc thus charged was removed and laid upon the roof of the large insulated can. This addition to the metal in connection with it does not sensibly influence its electrostatic capacity. The deflection observed was 122 scale divisions. The capacity of the condenser is approximately $\frac{\pi \times 2^2}{4\pi \times 1{\cdot}45} = \frac{1}{1{\cdot}45}$. The quantity of electricity with which it was charged was $\frac{1}{1{\cdot}45} \times \frac{100}{300} = \frac{1}{4{\cdot}35}$ electrostatic unit. Hence the quantity to give 936 scale divisions was

$$\frac{1}{4{\cdot}35} \times \frac{936}{122} = 1{\cdot}7637.$$

The bellows was worked vigorously for two and a half minutes, and in that time all the electrified air would be exhausted. The capacity of the can was 16,632 cubic centimetres, which gives, for the quantity of electricity per cubic centimetre, $\frac{1{\cdot}7637}{16{,}632} = 1{\cdot}06 \times 10^{-4}$. The electrification of the air in this case was positive; it was about as great as the greatest we got, whether positive or negative, in common air when we electrified it by discharge from needle

Table accompanying Mr. PHILIP DAWSON'S Paper on "The Modern Application of Electricity to Traction Purposes," read before The British Association, Section G.—*Ipswich*, 1895.

TABLE IV.—Electric Lines now in operation in Europe or by European Constructors. (a)

Name of Town.	When Opened.	Miles of Track.	Maximum Gradient.	Smallest Radius in Feet.	Gauge of Track.	No. of Motor Cars.	No. of Trailer Cars.	Tension in Volts.	No. of Kilowatts.	No. of Engines.	No. of Boilers.	Indicated H.P.	Type of Steam Engine.	No. of Dynamos.	How Driven.	Maximum Speed in Miles per hour.
Lines constructed by THE ELECTRIC CONSTRUCTION COMPANY.																
Liverpool (overhead) (b) (e)	March, 1893 ...	13	1 in 40	462	Standard	40	...	500	...	4	...	1,600	Horizontal Compound Condensing	4	Rope	30
South Staffordshire ...	January, 1893	8	1 in 40	40	3′ 6″	16	...	300	...	3	...	375	Horizontal Compound	3	Rope	8
Lines constructed by MESSRS. MATHER & PLATT.																
Bessbrook, Newry ...	October, 1885	3	1 in 50	55	3′	3	12	250	...	1 (Turbine)	...	62	Turbine	2	Belt	...
City and South London (b) (e)	December, 1890	6½	1 in 30	...	Standard	16 loco.	36	500	225	4	8	1,600	Vertical Compound	4	Belt	25, average 13·5
Douglas and Laxey ...	August, 1893–4	14	1 in 20	90	Narrow	13	12	500	...	5	...	450	Compound Condensing	5	Belt	...
Lines constructed by MESSRS. SIEMENS BROTHERS.																
Portrush (b)	1883	6	1 in 30	...	...	5	...	250	...	2	...	104	Turbines	2	Belt	...
Guernsey	March, 1892 ...	3	1 in 40	75	Standard	7	2	500	...	2	...	160	Semi-portable Compound ...	2	Belt	10
Panama	1893	2	1 in 24	45	...	7	...	440	...	3	...	60	... ...	2	... ...	...
Hobart Town	September, 1893	8½	1 in 17	70	...	20	...	500	...	2	...	600	High-speed Vertical	3	Direct-coupled	...
Line constructed by MR. MAGNUS VOLK.																
Brighton Beach (b) ..	August, 1893 ...	1	1 in 14	...	3′	2	2	100	...	1	...	12	Gas Engine	1	Belt	...
Line constructed by MR. HOLROYD SMITH.																
Blackpool (f)	1884	1	...	...	...	...	...	220	...	2	...	50	Semi-portable Compound ...	2	Belt and Shaft	...
Line constructed by MESSRS. CROMPTON & CO.																
Southend Pier (b)... ...	August, 1890 ...	1¼	...	...	...	3	3	200	...	...	...	...	... ...	2	Belt	14
Lines constructed on the THOMSON-HOUSTON SYSTEM.																
Bremen	May, 1892 ...	10	1 in 33	66	Standard	28	15	500	75 and 90	3	3	450	Horizontal Compound	3	Belt	8 to 10
Remschud	August, 1893 ...	5¼	1 in 10	60	Metre	13	...	500	...	4	3	450	Horizontal Compound	2	... ...	...
Hamburg	March, 1894 ...	26	1 in 20	60	Standard	160	150	500	...	3	...	170	2 continuous current transformers and 1 Engine	1	... ...	...
Gotha	May, 1895 ...	1¾	1 in 25	60	Metre	6	...	500	...	...	...	...	... ...	...	... ...	...
Erfurt	June, 1894 ...	7	1 in 16	48	Metre	29	17	500	100	3	3	450	... ...	3	... ...	...
Brussels	May, 1894 ...	18	1 in 16	66	Standard	88	47	500	350	8	7	900	Horizontal Compound	8	Belt	...
Leeds	November, 1891	5½	1 in 20	...	Standard	6	..	300	...	1	1	200	McIntosh & Seymour high-speed	2	Belt	8
Milan	September, 1893	4½	1 in 25	50	...	16	...	500	100	2	...	300	Vertical Compound	2	Belt	...
Lyons	July, 1894 ...	3·75	1 in 15	...	Standard	10	...	500	200	2	...	400	... ...	2	... ...	...
Havre	July, 1894 ...	8·75	1 in 18	...	Standard	40	...	500	200	3	...	900	Corliss Condensing	3	Rope	...
Bordeaux	1893	3·6	...	...	Metre	8	...	..	100	2	...	300	... ...	2	... ...	7½
Roubaix	December, 1894	10	...	...	Metre	18	...	500	100	3	...	450	... ...	3	... ...	...
Florence	April, 1891 ...	5	1 in 12·5	60	Standard	12	...	500	...	3	...	270	Vertical Compound	3	Belt	...
Liege	1893	2	1 in 30	82	...	5	...	550	...	2	...	240	... ...	2	Belt	...
Belgrade	1894	6·25	1 in 16	...	...	11	...	500	100	2	...	300	... ...	2	Belt	8
Munich	1895	1·5	...	...	...	12	...	...	...	...	...	...	... ...	...	... ...	...
Lines constructed by MESSRS. SIEMENS & HALSKE.																
Budapest (f)	July, 1889 ...	16	1 in 30	72	Standard	92	10	300	Each 4 @ 130 „ 3 @ 65	7	...	1,100	... ...	7	3 Rope 4 Direct ...	11
Budapest (Suburbs) ...	October, 1893	10½	1 in 50	157	Standard	20	...	300	...	...	...	800	... ...	...	... ...	14
Hanover	May, 1893 ...	14½	1 in 25	29½	Standard	32	12	500	130	2	...	400	Horizontal Compound	2	Direct	18
Dresden	July, 1893 ...	7½	1 in 29	49	Standard	16	16	500	80	2	...	240	Horizontal Compound	2	Direct	19
Genoa	May, 1893 ...	1½	1 in 15	131	Metre	4	...	500	100	1	...	150	Vertical	1	Belt	8
Barmen Rack Railway ...	April, 1894 ...	2	1 in 5	492	Metre	8	...	500	130	3	...	600	Horizontal Compound Condensing	3	Direct	4½
Barmen	September, 1894	1¾	1 in 18	72	Standard	7	...	500	...	...	...	...	Transformers from Lighting Station	...	... ...	10
Mulhausen	July, 1894 ...	3	1 in 35	49	Metre	9	7	...	...	...	...	...	... ...	...	... ...	12½
Lichterfeld (b)	May, 1881 ...	12	1 in 23	56	Metre	10	4	500	Each 3 @ 15 „ 1 @ 45	3	...	150	1 Portable Vertical	4	Belt	10
Lemberg	May, 1894 ...	6	1 in 14	56	Metre	16	...	500	150	2	...	400	Compound Condensing	2	Direct Coupled	8
Bucharest	November, 1894	4	1 in 40	49	Standard	6	...	500	50	2	...	150	Compound	2	Belt	10
Mödling (d)	October, 1883	4	1 in 66	98	Metre	8	7	500	20	4	...	186	Portable	6	Belt and Shaft	14
Frankfort (d)	1884	4½	1 in 32	98	Standard	10	6	300	20	2	...	100	... ...	4	Belt	...
Serajevo	May, 1895 ...	4	1 in 66	98	Metre ·760	5 loco.	8	300	65	...	...	...	... ...	1	... ...	...
Bochun	December, 1894	4½	1 in 54	49	Metre	5	4	500	50	2	...	150	... ...	2	... ...	...
Basel	May, 1895 ...	2	1 in 20	49	Metre	12	5	500	45	2	...	150	... ...	2	... ...	...
Lines constructed by COMPAGNIE DE L'INDUSTRIE ELECTRIQUE, GENEVA.																
Mont Saleve Rack Rlwy. (b)	1892	5¾	1 in 4	114′ 9″	Metre	12	...	600	165	2	...	500	Turbine	2	Direct	5
Clermont Ferand (d) ...	1890	4½	1 in 22	83	Metre	22	...	550	165	2	...	1,000	Compound	2 exciters	... ...	13
Stans	1893	2	1 in 9	164	Metre	3	...	550	33	1	...	150	Turbine	1	Belt	33
Chavornay	1894	2½	1 in 40	493	Metre 1·45	3	...	550	45	1	...	70	Turbine	1 exciter	... ...	...
Lyon Ecully	1894	2	...	65	Metre	3	...	550	70	1	...	110	... ...	1	... ...	...
Geneva	1894	3¾	1 in 18	82	Metre	8	...	550	152	2	...	440	... ...	2	... ...	...
Lines constructed by MESSRS. THE MASCHINENFABRIK OERLIKON.																
Mürren (c)	August, 1891 ...	2½	1 in 20	98	Metre	4	4	600	90	1	...	150	Turbine	1	Direct	...
Marseilles	1892	8	1 in 18	50	Standard	18	...	550	500	3	...	750	Horizontal Compound	3	Belt	8
Sissach Gellerkinden (c)...	May, 1891 ...	2	1 in 80	196	Metre	1	8	700	35	1	...	40	Turbine	1	Gearing ...	10
Zurich Central	February, 1895	2¼	1 in 18	49	Metre	14	...	550	44	2	...	240	Gas	2	... ...	...
Zurich	March, 1894 ...	3	1 in 18	49	Metre	16	...	550	66	2	2	360	Vertical	2	Belt	7
Lines constructed by MESSRS. (SCHUCKERT) ELECTRICITATS ACTIEN GESELLSCHAFT.																
Baden Vöslau	July, 1894 ...	6	...	...	Standard	9	9	500	...	...	...	...	... ...	...	... ...	7 to 12
Zwickin Sax	June, 1894 ...	4½	1 in 28·6	72	Metre	11	...	500	...	2	...	300	Horizontal Compound Condensing	4	Belt	...
Blasewitz	October, 1893...	...	1 in 33	12	...	9	8	...	...	2	...	340	... ...	...	... ...	12
Lines constructed by THE ALLGEMEINE ELECTRICITATS GESELLSCHAFT, BERLIN.																
Halle	May, 1891 ...	10	1 in 20	...	Metre	36	13	500	60	2	...	350	Horizontal	4	Belt	...
Gera	February, 1892	6	1 in 20	...	Metre	22	16	500	45	3	...	525	Vertical Combination	6	Belt	...
Kiew	May, 1892 ...	8¾	1 in 95	...	Standard	39	...	500	60	4	...	700	Vertical Combination	8	Belt	...
Breslau	June, 1893 ...	11½	1 in 40	...	4′ 7″	55	40	500	60	3	...	600	Vertical Combination	6	Belt	...
Essen	August, 1893 ...	13½	1 in 16	...	Metre	24	17	500	60	2	...	400	Vertical Combination	4	Belt	...
Chemnitz	December, 1893	13	1 in 30	...	Metre	28	20	500	60	2	...	350	Vertical Combination	4	Belt	...
Christiania	March, 1894 ...	4¾	1 in 15	...	4′ 7″	15	7	500	60	3	...	300	Vertical Combination	3	Belt	...
Dortmund	April, 1894 ...	7	1 in 40	...	4′ 7″	30	20	500	60	3	...	600	Vertical Combination	4	Belt	...
Lubeck	May, 1894 ...	8½	1 in 20	...	3′ 7″	28	20	500	60	3	...	450	Vertical Combination	4	Belt	...
Plauen	1895	2·2	1 in 12	...	Metre	9	...	...	72	2	...	200	... ...	2	... ...	...
Konisberg	1895	1·84	1 in 24	...	Metre	8	...	...	72	1	...	100	... ...	1	... ...	...
Relenburg	1895	3	1 in 11	...	Metre	7	...	...	45	3	...	330	... ...	6	... ...	...
Strasburg	1895	3·6	1 in 70	...	Standard	18	...	...	100	3	...	300	... ...	3	... ...	...
Lines constructed by MESSRS. KUMMER & CO., ACTIEN GESELLSCHAFT, DRESDEN.																
Blasewitz	October, 1893	2½	1 in 33	12 m.	...	9	8	400	...	2	...	340	... ...	...	... ...	9½
Vevey Montreux (d) ...	1888	6¼	...	...	Standard	...	...	...	...	1	...	240	Turbine	...	... ...	8
Lines constructed by INTERNATIONALE ELECTRICITATS GESELLSCHAFT, VIENNA.																
Teplitz Ecchwald ...	July, 1895 ...	5½	1 in 18	120	Metre	8	6	500	200	3	2	540	Steam Engines	2	Direct Coupled	..
Bielitz, Liegeunerwald ...	October, 1895	3⅛	...	...	Metre	6	2	550	100	1	2	180	Vertical Tandem	1	... ...	..
Lines constructed by MESSRS. GANZ & CO., BUDAPEST.																
Pozsony	1895	1	...	65	Metre	5	5	550	132	2	...	170	... ...	2	... ...	9½
Bleiberg	... ...	1¾	...	65	19″	2	10	200	3·3	...	...	10	Turbine	...	... ...	...
Mizserfa	... ...	1	1 in 19	91	24″	2	15	380	10	1	...	70	... ...	1	... ...	...
Maros-Szlatina	... ...	6½	1 in 19	98	3′ 7″	1	2	550	55	1 Partly Used	...	...	... ...	1	... .	...
Esolanyos	... .	2½	1 in 25	82	29″	1	2	550	15	1	...	30	... ...	1	... ...	...
Raglyas Alja	... ...	2	1 in 30	114	24″	2	60	550	110	2	...	160	... ...	2	... ...	...
Resitza	... ...	2½	1 in 20	72	27″	1	40	550	55	1	...	81	... .	1	... ...	..

(a) Where not mentioned otherwise the overhead conductor is used. (b) Third rail conductor. (c) This line runs electric locomotives. (d) Overhead conductor is a slotted copper tube in which collector slides. (e) The cars form a train, each car with motors wound directly on axles. (f) Conduit system.

LINES UNDER CONSTRUCTION

By MESSRS. SIEMENS & HALSKE.

Name.	Length.	Gauge.	Voltage.	No. of Motor Cars.	H.P.
BUDAPEST	12	Standard	300	..	2,400
BUDAPEST, UNDERGROUND	2¼	Standard	300	..	..
DRESDEN	30	Standard	500	57	..
PANKOW	2¼	Standard	500	8	300
BARMEN	2	Standard	500	..	..
GELSEN KERCHEN	17¾	Metre	500	..	..

MESSRS. KUMMER & CO., ACTIEN GESELLSCHAFT, DRESDEN.

Name.	Length.	Gauge.	Voltage.	No. of Motor Cars.	H.P.
FENBACH	7½	..	400	6	275

MESSRS. ELECTRIC CONSTRUCTION COMPANY.

Name.	Length.	Gauge.	Voltage.	No. of Motor Cars.	H.P.
MADRAS	9½	..	500	30	360
HARTLEPOOL	2½	..	..	5	200

MESSRS. GENERAL TRACTION COMPANY, LIMITED.

Name.	Length.	Gauge.	Voltage.	No. of Motor Cars.	H.P.
COVENTRY	6	3′ 6″	..	8	250

MESSRS. SCHUCKERT & CO.

Name.	Length.	Gauge.	Voltage.	No. of Motor Cars.	H.P.
AIX-LA-CHAPELLE	..	..	..	..	..
ULM	2½	..	..	8	..
DUSSELDORF	2	..	..	8	..

MESSRS. GANZ & CO.

Name.	Length.	Gauge.	Voltage.	No. of Motor Cars.	H.P.
BUDAPEST AND UJPEST	8½	Standard	..	10	480

THE ALLGEMEINE ELECTRICITATS GESELLSCHAFT.

Name.	Length.	Gauge.	Voltage.	No. of Motor Cars.	H.P.
SPANDAU	4	Metre	..	24	290
GENOA	10	Metre	..	67	1,200
KIEL	7½	3′ 7″	..	33	600
DANTZIG	11½	4′ 8″	..	35	600
STUTTGART	7½	3′ 3½″	..	50	..
CHEMNITZ	4½	Metre	..	10	75
LEIPZIG	27¼	4′ 8″	..	70	1,000
BILBAO	99¼	4′ 5″	..	28	525
BROMBERG	10	Metre	..	16	450
LUBECK	2½	3′ 7″	..	4	..

INTERNATIONALE ELECTRICITATS GESELLSCHAFT, VIENNA.

Name.	Length.	Gauge.	Voltage.	No. of Motor Cars.	H.P.
BIELITZ	3	Metre	350	6	180

CIE DE L'INDUSTRIE ELECTRIQUE, GENEVA.

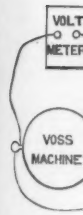
Name.	Length.	Gauge.	Voltage.	No. of Motor Cars.	H.P.
AUBONNE	1½	Metre	350	2	100
LAUSANNE	8½	Metre	550	14	520

MASCHINENFABRIK OERLIKON.

Name.	Length.	Gauge.	Voltage.	No. of Motor Cars.	H.P.
TETTNANG	2¾	Standard	..	2	250
NIJNI NOVGOROD	1½	Metre	..	15	1,350

THOMSON-HOUSTON SYSTEM.

Name.	Length.	Gauge.	Voltage.	No. of Motor Cars.	H.P.
HAMBURG EXTENSION	18½	..	500	87	2,500
ELBERFELD	2½	..	„	12	..
BARMEN	7	..	„	65	..
WIESBADEN	1½	..	„	7	..
ELBING	2½	..	„	10	..
LEIPZIG	25	..	„	135	..
LIEGE	7½	..	„	40	..
ROME	1½	Standard	„	10	..
BRUSSELS	4	..	„	20	..
BRISTOL	7	Standard	„	12	400
DUBLIN	16	5′ 3″	„	20	600
LYONS, ST. FONS	5½	Standard	„	10	150
LYONS, RESEAU	23½	..	„	100	2,500
ROUEN	20	Standard	„	10	900
MONTFERMEIL	3½	Metre	„	4	100
PESSAC	3½	Metre	„	50	300
VARESE	3	Standard	„	5	150
ALGIERS	5½	..	„	10	300
OPORTO	1½	Standard	„	3	150
CAIRO	25	..	„	50	..
MUNICH II.	1½	..	„	8	..
MUSSOCO	3¼	Standard	„	5	150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points. This is about four times the electric density which we roughly estimated as about the greatest given to the air in the inside of a large metal vat, electrified by a needle point and then left to itself, and tested by the potential of a water-dropper with its nozzle in the centre of the vat, in experiments made two years ago, and described in a communication to the Royal Society of date May, 1894.*

§ 4. In subsequent experiments, electrifying common air in a large gas-holder over water by an insulated gas flame burning within it with a wire in the interior of the flame kept electrified by an electric machine to about 6,000 volts, whether positively or negatively, we found as much as $1{\cdot}5 \times 10^{-4}$ for the electric density of the air. Electrifying carbonic acid in the same gas-holder, *whether positively or negatively*, by needle points, we obtained an electric density of $2{\cdot}2 \times 10^{-4}$.

§ 5. We found about the same electric density ($2{\cdot}2 \times 10^{-4}$) of *negative* electricity in carbonic acid gas drawn from an iron cylinder lying horizontally, and allowed to pass by a U-tube into the gas-holder without bubbling through the water. This electrification was due probably not to carbonic acid gas rushing through the stopcock of the cylinder, but to bubbling from the liquid carbonic acid in its interior, or to the formation of carbonic acid snow in the passages and its subsequent evaporation. When carbonic acid gas was drawn slowly from the liquid carbonic acid in the iron cylinder placed upright, and allowed to pass, without bubbling, through the U-tube into the gas-holder over water, no electrification was found in the gas unless electricity was communicated to it from needle points.

§ 6. The electrifications of air and carbonic acid described in Sections 4 and 5 were tested, and their electric densities measured by drawing by an air pump a measured quantity of the gas† from the gas-holder through an India-rubber tube to a receiver of known efficiency and of known capacity in connection with the electrometer. We have not yet measured how much electricity was lost in the passage through the India-rubber tube. It was not probably nothing; and the electric density of the gas before leaving the gas-holder was no doubt greater, though perhaps not much greater, than what it had when it reached the electric receiver.

§ 7. The efficiency of the electric receivers used was approximately determined by putting two of them in series, with a paraffine tunnel between them, and measuring by means of two quadrant electrometers the quantity of electricity which each took from a measured quantity of air drawn through them. By performing this experiment several times, with the order of the two receivers

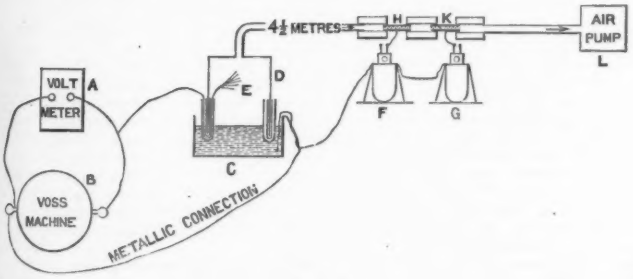

FIG. 2.

alternately reversed, we had data for calculating the proportion of the electricity taken by each receiver from the air entering it, on the assumption that the proportion taken by each receiver was the same in each case. This assumption was approximately justified by the results.

§ 8. Thus we found for the efficiencies of two different receivers respectively 0·77 and 0·31 with air electrified positively or negatively by needle points; and 0·82 and 0·42 with carbonic acid gas electrified negatively by being drawn from an iron cylinder placed on its side. Each of these receivers consisted of block tin pipe, 4 cms. long, and 1 cm. diameter, with 5 plugs of cotton wool kept in position by six discs of fine wire gauze. The great difference in their efficiency was no doubt due to the quantities of cotton wool being different, or differently compressed in the two.

§ 9. We have commenced and we hope to continue an investigation of the efficiency of electric receivers of various kinds, such as block tin, brass, and platinum tubes from 2 to 4 cms. long, and from 1 mm. to 1 cm. internal diameter, all of smooth bore and without any cotton wool or wire gauze filters in them; also a polished metal solid, insulated within a paraffine tunnel. This investigation, made with various quantities of air drawn through per second have already given us some interesting and surprising results, which we hope to describe after we have learned more by farther experimenting.

§ 10. In addition to our experiments on electric filters we have made many other experiments to find other means for the dis-

* "On the Electrification of Air," by Lord Kelvin and Magnus Maclean.

† The gas-holder was 38 cms. high and 81 cms. in circumference. Ten strokes of the pump raised the water inside to a height of 8·1 cms., so that the volume of air drawn through the receivers in the experiments was 428 cubic centimetres per stroke of the pump. This agrees with the measured effective volume of the two cylinders of the pump.

electrification of air. It might be supposed that drawing air in bubbles through water should be very effective for this purpose, but we find that this is far from being the case. We had previously found that non-electrified air drawn in bubbles through pure water becomes negatively electrified, and through salt water positively. We now find that positively electrified air drawn through pure water, and negatively electrified air through salt water, has its electrification diminished but not annulled, if the primitive electrification is sufficiently strong. Negatively electrified air drawn in bubbles through pure water, and positively electrified air drawn through salt water, has its electrification augmented.

§ 11. To test the effects of heat we drew air through combustion tubes of German glass about 180 cms. long, and 2½ or 1½ cms. bore, the heat being applied externally to about 120 cms. of the length. We found that, when the temperature was raised to nearly a dull red heat, air, whether positively or negatively electrified, lost little or nothing of its electrification by being drawn through the tube. When the temperature was raised to a dull red heat, and to a bright red, high enough to soften the glass, losses up to as much as four-fifths of the whole electrification were sometimes observed, but never complete diselectrification. The results, however, were very irregular. Non-electrified air never became sensibly electrified by being drawn through the hot glass tubes in our experiments, but it gained strong positive electrification when pieces of copper foil, and negative electrification when pieces of carbon, were placed in the tube, and when the temperature was sufficient to powerfully oxidise the copper or to burn away the charcoal.

§ 12. Through the kindness of Mr. E. Matthey, we have been able to experiment with a platinum tube 1 metre long and 1 millimetre bore. It was heated either by a gas flame or an electric current. When the tube was cold, and non-electrified air drawn through it, we found no signs of electrification by our receiver and electrometer. But when the tube was made red or white hot, either by gas burners applied externally or by an electric current through the metal of the tube, the previously non-electrified air drawn through it was found to be electrified strongly positive. To get complete command of the temperature we passed a measured electric current through 20 centimetres of the platinum tube. On increasing the current till the tube began to be at a scarcely visible dull red heat we found but little electrification of the air. When the tube was a little warmer, so as to be quite visibly red hot, large electrification became manifest. Thus 60 strokes of the air-pump gave 45 scale divisions on the electrometer when the tube was dull red, and 395 scale divisions (7 volts) when it was a bright red (produced by a current of 36 ampères). With stronger currents, raising the tube to white-hot temperature, the electrification seemed to be considerably less.

THE MODERN APPLICATION OF ELECTRICITY TO TRACTION PURPOSES.

By PHILIP DAWSON.

(*Read before Section G, Ipswich, September 16th*, 1895.)

THE history of electric traction extends over a period of well-nigh half a century. As in the case of most similar developments of applied science, that history is largely a record of disappointment and failure of tests which promised much from a theoretical standpoint, but which wholly failed to demonstrate any probable practical value.

The self-contained car carrying a sufficient store of energy for a given period of operation was long the only idea of the inventor. The first radical departure was made by Siemens at the Paris Exhibition of 1878, where a stationary generating plant furnished power to the motors on the cars, the rails serving as the connecting medium. This, and the success achieved by the cable tramway, turned the tide of experimentation toward the evolution of a workable system of sub-surface conductors. It was not, however, until 1884, when the overhead conductor was introduced, that any really efficient and practical solution of the problem seemed possible, and the succeeding four years were devoted to the elaboration of the many details connected therewith, and to the development of a type of apparatus which electrically and mechanically could withstand the excessive strains inseparable from tramway service.

It may be safely said that electric traction, as we to-day understand it, dates back no longer than 1888. That it should then have received, with all its imperfections, some measure of acceptance, is wholly due to the absolute necessity which existed in the United States for increased facilities of rapid transit. The horse tramway had failed to fill the demand—the introduction of the cable could only be contemplated where a great passenger traffic was assured beyond question—the steam tramway was heartily disliked by one and all. One great company (the West End Street Railway of Boston), having an enormous interest in the development of suburban residential property, which could not be efficiently served by any accepted means of traction, took the bull by the horns, and decided (and widely published) that it was prepared to investigate the question as to whether any new system of traction could meet its pressing needs and to adopt that one which could demonstrate success. The opportunity so offered, under conditions which assured experienced judges, a fair field, and a great reward for the successful competitor, was eagerly availed of. The modern history of electrical motive power begins with that competition. The result to the pioneer company can best be expressed in tabular form.

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Table I.—Results Obtained by the Introduction of Electrical Motive Power on the West End Street Railway, Boston, Massachusetts, U.S.A.

To September 30th of	1888.	1889.	1890.	1891.	1892.	1893.	1894.
Total miles of track	...	233·24	234·69	244·00	259·80	268·33	272·89
Miles electrically equipped	...	...	65·46	81·23	148·04	182·50	212·47 (*f*)
Number of horse cars	1,584	1,794	1,694	1,662	1,226	826	606
,, electric cars	...	47	337	469 (*a*)	1,028	1,346	1,509 (*g*)
Total revenue miles run	15,431,758	16,573,831	17,665,360	17,462,572 (*b*)	17,498,660 (*c*)	18,669,809 (*d*)	19,240,486 (*e*)
Electric revenue miles	...	...	...	4,588,186	9,622,000	14,189,054	16,794,961
Percentage of expenses to earnings	82	82	77	74·4	70·8	68	66·44
Investment of electrics	...	£85,270	£312,132	...	£1,188,890	£1,572,334	...

(*a*) The long cars introduced at this time, and now almost exclusively used on the company's electric lines, are almost twice the size of the regular two-horse car. (*b*) Electric mileage, 26·27 per cent.; horse mileage, 73·73 per cent. (*c*) Electric mileage, 48·63 per cent.; horse mileage, 51·37 per cent. (*d*) Electric mileage, 76·17 per cent.; horse mileage, 21·83 per cent. (*e*) Electric mileage, 87·29 per cent.; horse mileage, 12·71 per cent. (*f*) And 25 additional miles partially electrically equipped. (*g*) And 103 electric snow ploughs.

(Population of Boston, 1890, 448,477.)

We see that the decrease in the percentage of working expenses to gross receipts has varied almost directly in proportion to the introduction of electric plant. In 1888-9, before electricity was introduced, the percentage of expenses to earnings was 82 per cent. In 1890, as soon as the first outlying lines were electrically in operation, the percentage decreased to 77 per cent. In 1891, over one-fourth of the car mileage being electrical, the percentage is again decreased to 74·4 per cent. In 1892, with nearly one-half of the total mileage run by motor cars, the percentage drops to 70·8 per cent. In 1893, over three-fourths of the entire system having been electrically equipped, we find the ratio of expenses to earnings only 68 per cent., and the statistics of 1894 show the present operating expenses to be 66·44 per cent. of the gross receipts. This reduction has been made, notwithstanding the fact that the additional investment required for electrical plant and apparatus had to be provided for, and that such part of the former rolling stock, buildings, horses, &c., as was rendered useless or disposed of at a loss, had to be written off. Moreover, the introduction of heavy motor cars, and of a service higher in speed, required that the permanent way should be reconstructed in many places, and much heavier metals employed.

The results obtained in the whole State, of which Boston is the capital, are equally satisfactory.

Table II.—*Results obtained by the introduction of Electrical Motive Power on the Street Railways of the State of Massachusetts (pop.* 1890, 2,238,943).

(From the report of the Railway Commissioners of the State.)

	1888.	1894.
Total mileage of track... ...	533·59	929
Mileage of track electrically equipped	Nil	825
Total number of car miles run	23,244,767	36,722,978
Total number of passengers carried	134,478,319	220,464,099
Net earnings per car mile run, in pence	2·8	4·7
Percentage of operating expenses to gross income ...	81.07	69.5

In the past six years the total tramway mileage and passenger traffic has increased well-nigh 50 per cent. 825 miles, out of a total of 929, are now electric. The percentage of expenses to gross receipts has decreased from 81·7 to 69·5, and the net earnings per mile have nearly doubled.

These are the results obtained in but a single one of the United States and that by no means the largest. It may incidentally be said, however, that no city in the Union is more English in type than Boston, and no State more closely resembles England than Massachusetts both from a social and commercial aspect.

It is interesting to note from the "Tramway Manual," 1894, that the total tramway mileage of Great Britain is 960 miles; the number of passengers carried in the year, 1898,289,509; and the ratio of expenses to receipts 78·7 per cent.

Within the first six months of the Boston trials, accumulator cars and conduit-contained conductors, were hopelessly out of the race. The trolley wire and wheel had demonstrated an overwhelming superiority. The new system of mechanical traction was accepted throughout America.

Table III.—*Progress of Electric, Horse and Cable Lines in America,* 1890 *to July,* 1895.

Street railways.	1890.	1891.	1892.	1893.	1894.	July '95.
Mileage Total	9,037	10,599	11,665	12,186	12,527	14,020
,, Electric	2,523	4,061	5,939	7,466	9,008	10,752
,, Horse	5,400	5,302	4,460	3,497	2,243	1,957
,, Cable	510	594	646	657	662	632
,, Steam and various	604	642	620	566	614	679
No. of Cars. Total	32,108	35,877	37,399	40,499	41,668	45,756
,, Electric	5,592	8,892	13,415	18,233	24,849	35,004
,, Horse	21,970	21,798	19,315	16,845	11,507	6,438
,, Cable	3,795	4,372	3,971	4,805	4,673	2,080
,, Steam and various	751	815	698	616	639	*2,234

* Including cars towed by motor cars.

In 1890 there were 2,523 miles of electrically operated track and 5,592 motor cars within the U.S.A. and Canada. In July, 1895, 10,752 miles of trolley wire had been erected furnishing current for 35,004 electric cars. Approximately these figures mean an investment in equipment of £50,000,000 sterling.

European progress has been more slow. This is not unnatural, for there has been no such pressing necessity felt upon this side of the Atlantic under the more settled conditions which here prevail. In 1890 about 60 miles of electric lines were in operation. To-day there are approximately 500 miles of elevated conductors and 1,500 motor equipped cars, while the lines under contract easily equal, if they do not considerably exceed, the sum total of all that has heretofore been completed. The results are set forth in annexed tables, which, while undoubtedly incomplete, embody the latest information obtainable. (See Table IV.)

By far the greater proportion of European electric tramway installations are to be found in Germany, but during the past year great activity has been shown in France as well. Comparatively little has yet been done in the British Isles but there is every present appearance of extensive installations being shortly undertaken. Dublin, Bristol and Coventry are already in hand, and will probably have cars running during the present month. The electric tramways of the Isle of Man, South Staffordshire, Leeds and Guernsey are undoubted successes.

No other European country can, however, show such applications of electrical motive power to distinctively railway work as are to be found in the Liverpool Overhead Railway or the City and South London Underground.

On the question of tramways in general, the attitude taken in Great Britain is distinctly opposed to that of all other countries. It may be safely said that wherever else we turn we find the tramway regarded, if not as an unmixed blessing, certainly as an indispensable public convenience. British regulations are by far the most severe, and it is difficult to see why their stringency should not be relaxed to some extent. Our theory would seem to be that all other vehicles must necessarily take precedence of the tramcar. It would certainly seem, in this democratic age, that the vehicle which most greatly conduces to the comfort and convenience of the public at large should be accorded a better place.

With the gradual change from animal to mechanical means of traction, most, if not all, of the objectionable features of the tramway have been eliminated. Its social status has been distinctly raised in the public estimation, as its importance as a factor in municipal economy has won recognition. The great cable and electric systems of America have equal dignity with the steam railways of the country, represent enormous financial investment, and are much more closely connected with the daily life of the people.

If American and Continental experience has proved anything, electricity surpasses all other methods of motive power in its general fitness for tramway and light railway service. It admits of a constant service of comparatively light cars or trains at reasonable cost, of wide variations of speed, of elasticity sufficient to meet the demands of great temporary increase in passenger traffic, of re-equipment without extensive interference with the highway, existing cars, or any public service.

It is essentially clean, safe, and controllable, and no specially high class of employés are required in any department of a line. It has distinctly passed the experimental stage in every detail, and the apparatus has reached the point where interchangeability of parts and ease and simplicity of repairs can scarce be carried further. Every possible accessory is highly developed.

Curves, grades, switches, crossings, main and branch line service, present no difficulties to-day, however greatly they may have impeded the pioneers in the development of electric traction.

All that has been said is especially applicable to the trolley wire system, which is the only one that has received any wide acceptance. The conduit has still to demonstrate its efficiency on a large scale, although Buda Pesth and various Continental and American trial lines are now in operation. It may be considered certain that no sub-surface system will ever equal the elevated conductor, from the operator's point of view. Manifold difficulties in insulation, points and crossings, and connection between conductors and motors must be overcome. Moreover, it is more than doubtful whether the trolley wire and its supports are sufficiently objectionable to compensate for the great expense and manifold disadvantages attendant upon reconstruction of roadway, and interference with existing sub-surface sewers, gas and water pipes and mains, telegraph, telephone and lighting cables, &c. There is no reason to presume that an electric railway conduit should be cheaper or smaller than a cable railway

conduit. Drainage requirements are the same, and the question of effective insulation resolves itself largely into one of sufficient space. At all events, America is the home of both cable and electric railways, and we note that the engineers having now in hand the installation of trial electric conduit lines, are rigorously following the most substantial form of cable construction. In the English climate it is well known how great the difficulty is of securing proper insulation, and it would seem certain that we could not afford to put in anything smaller or less costly than is apparently deemed to be necessary across the Atlantic.

At all events, it may be taken (to quote Prof. Silvanus Thompson) that of all overhead wires the trolley is the least unsightly, and has the best excuse for its existence.

The "third-rail" system is applicable only to lines where the public has no access to the permanent way, or to toy-lines employing currents of extremely low potential.

In fact, a paper dealing with modern electric traction, without speculative reference to future developments, must be solely confined to the trolley system, and we will therefore proceed to discuss its component parts.

Upon the location and design of the generating station (with reference to the centre of current distribution), and the selection of the apparatus used therein, primarily depend the efficiency and economy of the whole system. The load is constantly varying, widely and unexpectedly, and the smaller the line the greater the fluctuation, and the consequent reserve power required. An electric tramway, operating five cars, might easily need 35 station I.H.P. per car, while a 50-car road should not require more than 15 I.H.P. per car in the power house. For units under 500 H.P., high speed rope-driven engines can advantageously be employed. Larger units require slow speed direct coupled engines of the Corliss type. Whatever the engine, it must be built especially for the work in question, and able to stand overloading to the extent of nearly double its normal output. In fact, the strains to be met approximate those to which the engines of a rolling mill are subjected. Extra heavy fly-wheels are always employed. Governors should be so constructed, that under any variation of load the speed should remain constant within 2 per cent.

The dynamos must also withstand heavy overloading, and as one pole is earthed, the best insulation must be employed. Very heavy magnetic inductions are allowed for to avoid sparking and the necessity of shifting brushes. From every point of view the over-compounded type of generator is the best. The design should be such that at no load the pressure between terminals should be 500 volts, increasing to 550 volts as the full load is thrown on.

While the ordinary practice is to employ compound-wound machines in parallel in the two-wire system, the three-wire system has been successfully adopted at Portland and St. Louis (U.S.A.), two generators being connected in series, one wire attached to the rails and the other two to alternate insulated sections of the trolley wire. The result has been to notably reduce the current in the rails, and the section of feeders. Very considerable difficulty has, however, been found in maintaining a proper balance.

As it often happens that single feeder cables are called upon temporarily to carry exceedingly heavy currents, automatic circuit breakers must be placed in all circuits.

The motors employed must be light, strong, and simple in construction—completely encased—able to run continuously for hours at rated capacity without undue heating, and to exceed that capacity by 50 per cent. when required without injury. The starting torque must be great. The average H.P. exerted by a motor at the car wheel probably does not exceed 20 per cent. of the maximum power it is expected to exert in starting a car under various conditions.

To get the best efficiency out of such a motor, it is necessary to have its point of highest efficiency at that H.P. at which the greatest amount of work is to be done. To minimise the losses through hysteresis, eddy current, and friction, and at the same time to obtain the required torque, it becomes necessary to use the greatest number of armature turns compatible with easy running and absence of heat and sparking. To ensure the latter it has been found necessary to use very heavy magnetic inductions, such as 100,000 C.G.S. lines of force per square inch in the yoke, 60,000 C.G.S. lines in the air space, and 80,000 C.G.S. lines in the armature core.

It is universally considered that the drum armature, wound so that coils of different potential do not cross each other ("Eickemeyer") is most advantageous. All coils are made separately on forms and then bound down into wedge-shaped grooves cut in the face of the armature core. The use of paper insulation between the armature discs has been discarded, and the formation of Foucault currents is prevented by heating the discs, thus covering their surfaces with a black oxide which suffices as insulation.

The standard motor used on European and American electric lines weighs approximately 1,500 lbs., and is rated at 25 H.P.; that is to say, it will exert a horizontal effort of 800 lbs. through a 33-inch wheel continuously at normal speed.

Every variety of gearing has been tried in turn, in order to secure the most efficient method of reducing the speed of the armature and transmitting its action to the car axles. Double and single reduction spur gear, bevel gear, belts, single and double chain gear, and worm gear, have all been submitted to most extensive tests.

Practically, all motors are now standardised on the single reduction spur and pinion, from which gearing an efficiency of, approximately, 95 per cent. is now obtained. The pinions are of steel, and the spur wheels of cast-iron. Epicycloidal teeth are almost universally employed. The gears are always run in oil, and the life of the pinions and spur wheels, which in the old double reduction type of motor was, respectively, 9,000 and 29,000 miles, has been more than doubled.

Practically, the only method of control now employed in traction work is the series parallel system. This consists in the use of two or more motors per car, which by means of a special device are thrown into different combinations. These are shown in the diagram, and a typical controller is before you. The introduction of the series parallel controller has resulted in a very great saving of power at starting, while four different speeds are attained without the waste of current in the resistances previously employed, and with a high efficiency in the motors. Reversal is effected by a separate switch, and interlocking gear prevents the motors being reversed until the current is turned off.

We have before us a model motor truck, showing the standard construction now utilised by most large American roads, and which is also employed by all the English tramways now under electrical construction. The model is so made as to show three styles of truck employed for supporting cars of different lengths, and it is fully equipped with two "G.E. 800" motors and their gearing. It may be said that the introduction of electric traction has revolutionised running gear. The great addition to weight made by the motors and gearing has rendered it necessary that efficient methods be used for cushioning and suspending the motors upon their axles, while maintaining a rigid connection between motor and axle.

Consequently the truck is to-day made so that it relies not at all upon the car construction for strength or support of the mechanism. The use of a reliable and efficient truck is quite as important as the employment of well constructed motors. You will see that the design of the model truck is practically that of a continuous truss such as would be used in canti-lever bridge work. Every care is taken to evenly support the car body for its whole length, and to use such springs at the different points as will most readily accommodate themselves to both heavy and light loads. It has been found that the four-wheeled truck can be satisfactorily used for the support of car bodies up to 22 feet in length. For longer bodies, bogie and radial trucks are employed. Many different types of bogies have been employed in order to get the maximum traction weight upon the driven axles; but, as yet, no one can say positively which of the several variations is the best. The six-wheel radial truck has been largely introduced with the desire of doing away with the waste of power due to skidding and grinding of the wheels on curves of small radius. It is composed of three independent two-wheel trucks pivoted together, the two end trucks carrying the greater part of the load and the motors. It cannot yet be said that this truck is wholly satisfactory, as it has a tendency to derailment. It is indispensable that mechanically-propelled cars in populous cities should be provided with thoroughly reliable safety apparatus, and you will note how very substantially the brakes upon the model truck are made. Several different systems of supplementary braking apparatus are in use, and on all roads operating heavy grades it is customary to employ air, electric, or additional track brakes to supplement the ordinary hand brakes. Safety fenders of many different types are also used to prevent the possibility of any person getting under the wheels, should he fall in front of a moving car. Sand boxes, actuated by levers on the driver's platform, are always provided.

The British tramcar, having seats on the roof, requires a somewhat different style of trolley from that usually employed on American and Continental lines. Both types are before you, and it is scarcely necessary to further explain them. You will see that swivelling arrangements are provided whereby the trolley will easily and certainly follow the trolley wire from a point directly above the car roof to a point of 8 to 10 feet off to one side of the track. This adaptability of the trolley to a considerable variation of the wire from a direct line greatly simplifies construction, and enables the wire (as at Bristol and South Staffordshire) to be hung from short arms along one side of the track. In a few cases constructors have preferred to use scraping contacts, running along the under side of the wire rather than the wheel, but the great mass of opinion is strongly in favour of the use of the wheel contact.

Such adverse criticism as has been made upon the use of elevated wires for electric tramway service has largely arisen from carelessness in erection, and, in the earlier days, from the fact that the various accessories were still in an experimental stage, and unsightly apparatus was made up on the spur of the moment to meet exigences as they arose. The first electric lines, both European and American, were great sinners in this respect, and the clumsy cobwebs of wires which they erected were undoubtedly most objectionable. With the enormous increase in traction business, it became worth while, from a business standpoint, for many expert mechanics to devote themselves to the elaboration of these details, and to the perfection of the apparatus required in their manufacture. Special poles, insulators, suspension devices, and all the many appliances required for crossings, branches, terminals, &c., have consequently been developed, and have greatly added not only to the efficiency of equipment, but to ease in erection and workmanlike appearance. A set of approved apparatus, such as is used in the construction of various British lines, is before you, and you will note that they are compact, strong, and not likely at a height of 21 feet in the air to be unduly conspicuous. In many Continental cities, the municipal authorities have prescribed that in all cases, where possible, the span wires supporting the trolley line should be attached directly to the house fronts by means of rosettes of ornamental design. Injurious effects to the buildings from vibration is avoided by the insertion of springs or India-rubber cushions. Where this method is used all objectionable features are minimised to the greatest possible extent.

The span wire system of construction, by which the trolley wire is held directly over the tracks is undoubtedly the most efficient, especially where high rates of speed are to be run through broad streets. Where the tramway track is along a single side of the highway, suspension from single bracket arm poles possesses the same advantage.

Much has been done on the Continent and in England in deve-

loping handsomely ornamented poles, which do not detract from the appearance of the street, and in many places electric arc and incandescent lamps are supported upon the same poles as carry the tramway wires. Several designs now in use are illustrated in the drawings before you. The employment of underground feeders adds much to the sightliness of the installation.

For the separation of a line into sections so that an accident upon one portion may not interfere with the whole line, for protection against lightning, &c., ingenious apparatus has been developed, samples of which are on the table. In a few places double conductors are employed in order to avoid the necessity of using the rails for the return circuit, and the consequent bonding of joints required. These are, however, isolated instances, and the only large system worked in this manner is that of Cincinnati. It will easily be appreciated that such advantage as may be secured by the use of a double overhead conductor, is more than compensated for by the resultant increase in the number of wires suspended over the street.

To ensure an easy path for the return current is of great importance, and on the earlier roads, which largely trusted to the earth as a return, very serious difficulties were soon encountered. Heavy currents of electricity, circulating through the metallic pipes and conduits along the line of the route caused their rapid corrosion. At first, enormous falls of potential were allowed, but now-a-days it is rare that the fall of voltage on any line is allowed to exceed 20 per cent.

It has now been definitely ascertained that heavy copper joints between the ends of the rails should always be employed and the rails relied upon for the return to the extent of their current carrying capacity. When that is exceeded, insulated return circuit feeders should be run back to the power house. Bare copper supplementary wires laid the length of the track, are utterly useless. The latest and most approved form of bond is the "Chicago" railbond which during the past year has come into very extensive use in Europe as well as in America. It consists of a copper rod having tubular terminals, which are inserted into holes through the web of the rail. The terminals are then expanded and wedged into solid contact with the metal of the rail by driving into each terminal a drift pin about $\frac{1}{16}$th inch larger than the thimble. This makes as nearly as possible perfect contact between the two metallic surfaces, excluding air and moisture, and preventing corrosion or electrolytic action in the connection. It must be borne in mind that the only contact which can be at all relied upon is that between the bond and the interior surface of the hole in the rail, and that the surface of copper in contact with that surface should be at least six times the section area of the bond.

Electric welding may demonstrate its success as a means for insuring the return circuit, but it cannot be said as yet whether or no the results have been such as to warrant its extensive introduction. It must stand the test of some years' trial. Over 100 miles of track have been welded at joints in the United States, and the work is still going on. It is too early yet to form an opinion as to its relative value compared with the system of heavy bonding which has now secured the widest approval. Specimens of bonds are exhibited.

As electric traction is applied on a more and more extensive scale, and great numbers of cars are operated by individual roads, the question of how to distribute current most economically attains great proportions. We have already referred to the three-wire system as having a considerable value. Three-phase distribution is also being tried upon an extensive scale in many places. The Dublin Southern Tramways, on the 8½-mile line which is now being constructed by the British Thomson-Houston Company, will employ a combination of continuous current and of three-phase alternating current transmitted at a pressure of 3,000 volts to two sub-stations respectively 3½ and 8 miles away from the generating station. Each sub-station contains two 60-kilowatt rotary transformers. At Sacramento, Cal., a water power 23 miles away from the line supplies 4,000 horse-power for the needs of that city, current being transmitted at a pressure of 11,000 volts. At Portland, Ore., current at 6,000 volts is transmitted from a water power 20 miles distant from the line. At Lowell, Mass., current generated by steam is transmitted to sub-stations respectively 7 and 15 miles from the power-house at a pressure of 5,000 volts. In Switzerland we find several interesting applications of water power carried from a long distance at convenient voltages and transformed for railway and traction use to the ordinary potential of 500 or 600 volts. At Lugano, Messrs. Brown, Boveri & Co., are undertaking an interesting installation, in which the cars are furnished with three-phase motors. A double trolley wire is used and the rails act as the third conductor.

All this work is in the direct line which will some day lead to an extensive competition with steam as the motive power for railway services. Throughout America we find extensive application of electric traction to mining tramways, for the electric motor readily adapts itself to the contracted space of galleries and drifts, to the handling of freights in cities, goods' yards, and factories. Messrs. Ganz & Co., of Buda Pesth, have done most interesting and valuable work in this particular line.

It is unnecessary to refer to the equipment of the City and South London Railway and the Liverpool Overhead. These have been already thoroughly discussed and described before the learned societies, and the elevated railway at the Chicago Exhibition has also been referred to *in extenso* in the technical press.

The Metropolitan Elevated Railway of Chicago is now in full operation, running trains of four cars of which one is equipped with motors. The weight of the complete motor car is nearly 30 tons, and the train complete will weigh approximately 100 tons. The speed, including stops will be 13 miles an hour with the present equipment, but it is proposed to shortly operate six car trains at a speed of 15 miles per hour. The Baltimore and Ohio Railway have already in operation the first of a number of 96-ton electrical locomotives with which they propose to operate the 2½ miles of tunnels through which their lines run at Baltimore.

The dimensions of these locomotives are as follows:

No of trucks (per locomotive) ...	2
„ motors „ „ ...	4
Weight on driving wheels	192,000 lbs.
No. of driving wheels	8
Draw bar pull	42,000 lbs.
Starting draw bar pull	60,000 lbs.
Gauge	4 feet 8½ inches.
Diameter of drivers	62 inches.
Length over all	35 feet.
Height to top of cab	14 feet 3 inches.
Wheel base of each truck	6 feet 10 inches.
Extreme width	9 feet 6½ inches.
Diameter of sleeve bearings	13 inches.

Each motor is rated at 360 H.P. and takes a normal current of 900 ampères. An average speed of 15 miles an hour is obtained. The trains handled by these motors weigh approximately 1,200 tons.

Several of the greatest trunk line railways in the United States have commenced the equipment of short branch lines with electrical plant. The Pennsylvania Railroad Company has 8½ miles equipped with trolley wire, over which their standard cars will be drawn by electric locomotives at a speed of 45 miles an hour. The New York, Newhaven and Hartford, Railroad Company has had some seven miles of electrically equipped track in operation for some months, with 30-ton 42-feet cars, under the ordinary conditions of steam railway service. Other lines are preparing to follow their example. It is undoubtedly the case that the results obtained in America have conclusively proved that electricity is cheaper than steam wherever comparatively short lines with frequent stops are to be worked, and we are yet far from knowing the limit to which the comparative economy of electricity extends.

In the limited time at our disposal, it is naturally impossible to more than touch upon the many interesting features which are worthy of attention. I would, however, like to say a word concerning the diagrams before you.

The first shows the path taken by the current along the trolley-wire and back by the metals.

The second and third contrast efficient and non-efficient methods of rail-return, with especial reference to the avoidance of danger to pipes and mains through electrolysis.

The fourth shows the positions into which the motors are thrown by the "K" controller.

The sixth exhibits the switchboard connections employed on the Bristol electric tramways, where the first cars ran last Tuesday with complete success.

The seventh shows various methods of connecting line and power-house.

There would seem to be no reason why the same results which have been attained in America should not be reached in Great Britain. Certainly European progress seems to indicate that there is little or no difference between the conditions and requirements which must be met on either side of the Atlantic. We hear on all sides the demand for additional light railways, and to postpone their construction is to heavily handicap a great portion of our population in the competition which to-day exists with foreign producers. The tramway as it now is known in this country, is behind the times, and our facilities for rapid transit most inadequate. There is much which we can safely take from the experience of other countries in its development and extension.

In the face of the numerous and successful Continental installations, it is impossible to reasonably maintain that the electric system fails to meet the requirements of City and suburban transit to an extent unparalleled by any other means of mechanical traction. The conditions of modern metropolitan life imperatively demand that our ever-increasing population be afforded vastly improved means of intramural circulation. Our over crowded centres can no longer accommodate the great army of workers and their families, and access to outlying suburban districts should be facilitated by every possible means. For hygienic reasons alone, it is indispensable that the accessible residential zone surrounding our greater cities should be extended to the utmost limit.

The steam railway cannot efficiently or economically fill this demand, and animal traction is hopelessly inadequate. The trolley system does fill it absolutely, and has well-nigh every advantage that can be asked from an ideal system of traction. The overhead wire is its single objectionable feature, and it would seem not unreasonable to say that so comparatively small a drawback is of but little moment compared with many manifest advantages.

EXPERIMENTS FOR IMPROVING THE CONSTRUCTION OF PRACTICAL STANDARDS FOR ELECTRICAL MEASUREMENTS.

(*Submitted to Section A, September 18th*, 1895.)

Report of the Committee, consisting of Prof. CAREY FOSTER (Chairman), Lord KELVIN, Profs. AYRTON, J. PERRY, W. G. ADAMS and Lord RAYLEIGH, Drs. O. J. LODGE, JOHN HOPKINSON and A. MUIRHEAD, Messrs. W. H. PREECE and HERBERT TAYLOR, Prof. J. D. EVERETT, Prof. A. SCHUSTER, Dr. J. A. FLEMING, Profs. G. F. FITZGERALD, G. CHRYSTAL and J. J. THOMSON, Messrs. R. T. GLAZEBROOK (Secretary) and W. N. SHAW, Rev. T. C. FITZPATRICK, Dr. J. T. BOTTOMLEY, Prof. J. VIRIAMU JONES, Dr. G. JOHNSTONE STONEY, Prof. S. P. THOMPSON, Mr. G. FORBES, and Mr. RENNIE.

Appendix.—*On Magnetic Units.* By O. J. Lodge.

The work of testing resistance coils at the Cavendish Laboratory has been continued. A table of the coils tested is given.

Ohms.

No. of coil.		Value of coil.	Temperature.
Nalder, 4,341 ...	No. 422	·99349	11°·8
Nalder, 4,650 ...	No. 423	1,000 (1 − ·00041)	15°
Elliott, 309 ...	No. 424	·99902	13°·1
Elliott, 310 ...	No. 425	·99915	13°·2
Elliott, 311 ...	No. 426	·99956	13°
Elliott, 312 ...	No. 427	·99911	13°·2
Elliott, 313 ...	No. 428	·99903	13°
Elliott, 314 ...	No. 429	·99912	13°·1
Elliott, 315 ...	No. 430	9·9991	11°·7
Elliott, 316 ...	No. 431	9·9873	11°·6
Elliott, 317 ...	No. 432	9·9914	12°
Elliott, 318 ...	No. 433	100 (1 − ·00014)	14°·1
Elliott, 319 ...	No. 434	100 (1 − ·00027)	14°
Elliott, 320 ...	No. 435	100 (1 − ·00023)	13°·9
Nalder, 4,651 ...	No. 436	·99899	13°·8
Nalder, 4.653 ...	No. 437	9·9846	12°
Nalder, 4,654 ...	No. 438	9·9833	12°·1
Nalder, 4,655 ...	No. 439	100 (1 − ·00068)	14°·3
King Mendham	No. 440	1·00078	15°·2
Nalder, 4,934 ...	No. 441	·99926	14°·1
Paul, 36 ...	No. 442	9·9969	13°·7
Wigston, 449 ...	No. 443	9·9988	14°·3
Wigston, 440 ...	No. 444	·99888	17°·3
Wigston, 450 ...	No. 445	100 (1 − ·00030)	17°·3
Wigston, 453 ...	No. 446	1,000 (1 − ·00067)	17°·3
Nalder,* 4,561...	No. 409	1,000 (1 + ·00039)	15°·2

* Retested (see Report for 1894).

The resistance coils referred to in the last report as defective in insulation have been refilled, and up to the present their insulation has proved satisfactory.

The set of standards ordered from Germany has not yet arrived. When they are received a careful comparison will be made between their values and those of the standards of the Association.

During the year the committee have had under discussion a paper on magnetic units prepared by Dr. Lodge and printed as an appendix to this report.

The committee recommend that they be reappointed; that Prof. G. Carey Foster be chairman, and Mr. R. T. Glazebrook secretary.

APPENDIX.

Magnetic Units.

To the British Association Committee on Electrical Standards.

Believing that the committee is impressed with the convenience of affixed names to some of the more important units connected with the magnetic circuit, I beg to suggest the following considerations and recommendations, which I will write out as briefly as possible. The statements are intended to be precise in their terms; but in several cases alternative forms of definition are given.

1. That the unit coefficient of self-induction, though frequently useful, is by no means one of the most fundamental units, but should be defined in a suitably subordinate manner, with reference to other and more important quantities.

2. That it would be a mistake so to define it as to discourage the employment of the same term for as many other quantities of the same "dimensions" as possible; especially for the unit coefficient of mutual induction, and for unit "permeance."

3. That the essentially different quantities, commonly called H and B, should be carefully kept distinct, although their measures in air have been conventionally so arranged as to be numerically equal.

Summary of Known Facts and Definitions.—H being the intensity of magnetic force at a point, or the slope of magnetic potential (ω),

$\omega_a - \omega_b = \int_a^b H\,ds$, along any portion, $a\,b$, of a line of force;

and in a closed magnetic circuit the circutation of H is equal to 4π times the total electric current through the area bounded by the magnetic circuit; or,

$$\text{cycle } \int H\,ds = \text{circuitation of } H = \iint 4\pi c\,dS = 4\pi C,$$

or, at any point of space,

$$\text{curl } H = V\nabla H = 4\pi c;$$

where c is current density.

If the electric circuit consists of n turns of wire threading the magnetic circuit, and each conveying the current, c_1, then $C = n c_1$.

First Quantity to be Named.

4. The first thing requiring a name is this quantity *magnetic potential*, sometimes called *magneto-motive force*; a quantity spoken of and measured, not inconveniently, but with insufficient generality, by electrical engineers as ampère turns. It has been proposed (by Mr. Heaviside, for instance), that it be called *gaussage*, and that its C.G.S. unit be 1 *gauss*.

5. The circuital gaussage round a closed curve is 4π times the total electric current through the area bounded by that curve.

In the case of a magnetic circuit wound with wire the gaussage is is $1\frac{1}{4}$ times ($\frac{4\pi}{10}$, or 1·2566) the ampère turns threading that circuit.

Note.—It *may* be best to retain the word "gaussage" for the whole of a closed circuit only, and to speak of the difference of magnetic potential between two points as the fall of gausses or the "gauss fall" from a to b.

6. The gaussage, or gauss fall, in any portion, $a\,b$, of a magnetic circuit, is measured by the change in the potential energy of a unit pole as it moves from a to b by any path which involves neither the cutting of magnetic layers nor the encircling of currents (a long channel being imagined for its motion through solid material, if necessary). Or, more practically, it is measured by the induction through a long narrow tube whose ends are at a and b respectively, divided by the permeance of that tube. (*Cf.* Chattock on a magnetic potentiometer, *Phil. Mag.*, July, 1887.)

In practice, however, gaussage is frequently calculable from the ampère turns to which it is due.

7. Intensity of magnetic force, or H, will be naturally expressed as gauss fall per centimetre, or the *gauss gradient*. For instance, the earth's horizontal intensity at some place is ·18 gauss per linear centimetre, or 5·4 gausses per foot.

Note.—H should not (strictly speaking) be expressed as so many lines per square centimetre; that mode of expression should be reserved for induction density, B. H is the cause, and should be thought of as the slope of magnetic potential, B is the effect. In a medium of so-called unit permeability the two quantities are numerically equal, but they should not be confounded; any more than the slope of electric potential, or electric intensity (e), should be thought of as identical with current density, even in a medium of unit conductivity.

8. The gauss gradient inside a long or closed magnetic solenoid of length l, wound uniformly with n turns of wire, each conveying the current c_1, is $4\pi n c_1/l = 4\pi n_1 c_1$; where n_1 is the total number of turns of wire (in all the layers) to the linear centimetre.

This is the measure of H in the interior of such a solenoid, quite irrespective of the material with which it may happen to be filled.

Second Quantity to be Named.

9. The second quantity requiring a name is the *total induction* in a magnetic circuit, also called "total flux," "total lines," "electromagnetic momentum," and "electrotonic state." It is the quantity whose time rate of variation gives the voltage induced in an electric circuit surrounding it once. It is proposed that its practical unit be called a "weber," and be defined as equal to 10^8 C.G.S. lines (or unit tubes) of induction.

(Denote the quantity for the present by N, and its density by B.)

Summary of Known Facts.—e being the intensity of electric force, or the slope of electric potential, or the volt gradient at a point; the circuitation of e = the induced E.M.F. in a closed circuit = the rate of change of induction through it;

$$\text{or} \qquad \text{cycle } \int e\,ds = E = -\dot{N} = -\iint \dot{B}\,dS;$$

or, at any point of space,

$$\dot{B} = -\text{curl } E = -V\nabla e.$$

Through a simple closed electric circuit of constant resistance,

$$N = -\int E\,dt = \int R C\,dt = R Q.$$

10. The total induction through any area may be practically measured by suddenly surrounding it with a closed wire circuit of n turns connecting the terminals of a ballistic galvanometer, and measuring the quantity of electricity thereby impelled through the galvanometer. The induction is equal to the quantity so impelled, divided by n times the resistance of the circuit. If the quantity is 1 coulomb, and the resistance 1 ohm, the induction is $1/n$th of a weber.

Or, otherwise, if the induction through any boundary changes at the rate of 1 weber per second, the E.M.F. excited in that boundary is 1 volt.

In the case of a wire circuit through which induction is varying at the rate of a weber per second, 1 volt is excited *in each turn* of the wire.

(To be continued.

DAME TELEGRAPH AND MISS TELEPHONE.

The following verses were recited by their author, Mr. Alexander McEwan, at the entertainment inaugurating the opening of the trunk telephone system, given in the Reception Rooms of the Postmaster-General in the new General Post Office on July 1st ult., under the direction of the engineer-in-chief.

Many provincial cities and towns, as our readers will remember, were given an orchestral and vocal entertainment by telephone at the hands of the St. Cecilia Orchestral Society of the Central Telegraph Office, assisted by a few friends.

The lines which follow justly shared the honours of that most successful evening:—

Dame Telegraph sat with a forlorn air,
A bursting heart, and a vacant stare;
Of all her troubles that bordered on grief,
This, this was the worst, the last, the chief.
In fact I may say she was totally "Dis,"
And plainly she showed a most shocking "Resis."
She was heard with a quivering lip to moan,
"I s'pose now they'll clear me of house and 'ohm,'
And while they're under this terrible spell,
I feel they won't leave me a single 'cell.'

For years I have borne for John Bull a 'charge,'
I've done all his work and my family so large;
There's poor Double Needle advanced into years,
And my Bright little Bell who still sings to my ears.
There's Morse who for years has been making his mark,
And old Single Needle still good for a lark;
And Sounder the merry, Hughes, Duplex, and Quad,
Preece knows what I've suffered to keep them well shod.
Then Wheatstone the speedy I will never disown
My dear darling child, his mother's fond own.

'Tis true that our last child does much to perplex,
But he's scarce cut his teeth yet, poor dear Multiplex.
My troubles are sad but it grieves me to think,
That perhaps his wet nurses have taken to drink;
Tho' those who attend him are kind and forbearing,
There is some excuse if they give way to swearing.
And then what with switches, with relays, and galvos,
My cares I might tell out in volleys and salvoes.
But telegraph troubles I may say without chaff,
Are not all confined to the technical staff!

One day to our home Miss Telephone came;
Oh! such a dear creature and such a nice name,
Her ways were so simple, so quick, and so neat,
John Bull told me plainly I'd find her a treat.
There wasn't a language to wrinkle her cheek,
For all she spoke fluently, e'en Billingsgate Greek;
John Bull made me share out my home with this lady,
But I've an idea she's just a bit shady;
I'm sure she'll make mischief—that's one of my fears,
She's so fond of repeating all things that she hears.

She cares not a jot what people may say,
But 'outs' with it sharp in a cold-blooded way;
In fact, what she hears from some merchants and brokers
Is worse than you'd hear from coal porters and stokers.
Then when I ask John for a few feet of wire,
He screws up his face and begins to perspire;
But Miss Telephone tells him quite plump and pat,
'Now, John, wire me up like this and like that.'
He does as she bids him, not the slightest reduction,
And smiles as he tells me he's 'settling Induction.'

Into all sorts of company Miss Telephone goes,
From a prince to a peasant she'll list to their woes;
In a palace she'll sit hobnobbing with dukes,
She's at home at the Woolsales, at Gaze's, or Cook's,
And even in our churches she'll sit with mute air,
And join in the anthems, the chants, and Lord's Prayer;
Next day she'll be found by the river and docks,
And talking to bargees in language that shocks.
But at home in the Office my life has been spent,
With a turn at some Racing or Special event.

Yes, at Epsom and Ascot my John has been proud,
He speaks in my praise to the country aloud;
But haven't I slaved with my house, and all in it,
To clear off John's work at 400 a minute?
Why! Kelvin (once Thomson), and Siemens and Preece,
Have said I'm the cause of Great Britain's increase;
But they're off with the old love, and on with the new,
And my friends perhaps will fall to the small 'faithful few.'
And my life when it looms up on History's page,
Will read 'For a season she was all the rage.'

But stay, am I not in these thoughts over zealous,
And making myself of Miss Telephone jealous;
Has the fire of ambition so calcined my heart,
That I refuse to afford to this damsel a start?
Oh joy! may we not yet discover one mind,
For mutual help and assistance inclined;
And now my heart lifts, and bids me inquire,
In what way to cheer her, and quickly inspire
With a zeal for the service, and England and home,
My neighbour and kinswoman, Miss Telephone.

In friendly contention we'll work side by side,
The honours of labour and progress divide;
In the 'good time that's coming,' we'll each bear a part,
And help one another with Hand, Head, and Heart,
Our mission to spread o'er the world joy and peace,
And to draw of the earth's fruitful yields an increase.
To weld man to man in the bondage of love,
Fulfilling the mandate of high Heaven above,
Until through the Ages resounds with acclaim,
'Be glory to God in the Highest!' Amen!"

Alexander McEwan,
Central Telegraph Office.

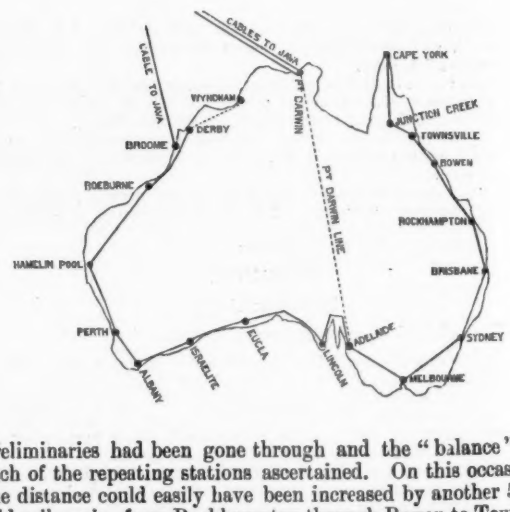
LONG-DISTANCE TELEGRAPHY.

[communicated.]

Some interesting experiments in long-distance working on land lines took place here (Australia) recently, permitting communication by means of automatic repeaters over almost the whole of the Australian continent.

Early in the present year Mr. H. W. Jenvey, electrician, Victorian Postal Department, was despatched by the Postmaster-General of Victoria to report on the telegraph and telephone systems of Western Australia. This was the outcome of delays in the business to and from Western Australia. Several deputations from the Chamber of Commerce and other business corporations having protested against these delays, it was in compliance with a special request from the Western Australian Government that an officer from the Victorian service was asked to personally investigate the arrangements and provide an independent and expert report. Mr. Jenvey's stay in the Western colony was of about two month's duration, advantage being taken of his presence in Perth, at which place his head-quarters were, to see what could be done in the way of prompt communication.

On Sunday, April 28th, Melbourne was enabled to speak to Perth with facility through repeaters at Adelaide, Port Lincoln, Eucla, Israelite Bay, and Albany, over 2,571 miles of line. This distance was subsequently increased on Sunday, May 5th, to 5,709 miles, when Broome in Western Australia was placed in communication with Rockhampton, Queensland, through repeaters at Perth, Albany, Israelite Bay, Eucla, Adelaide, Melbourne, Sydney, and Brisbane, conversations being carried on at a rate of 20 words per minute after the



preliminaries had been gone through and the "balance" at each of the repeating stations ascertained. On this occasion the distance could easily have been increased by another 500 odd miles, viz., from Rockhampton through Bowen to Townsville, Queensland, only that the officials at Bowen had chafed somewhat at a slight unavoidable delay in getting switched on right through, and going home to dinner had omitted to leave the Townsville section in circuit. The latter station had been speaking to Melbourne a few minutes previously.

Nothing further was done by way of attempting to annihilate distance until Sunday, May 26th, when on this occasion of trying all former efforts were eclipsed, and the result was a most pronounced success. This time a total

distance of 7,313 miles of land line was distinctly spoken over, viz., from Cape York, the most northern telegraph station in Queensland to Derby in the north of Western Australia, automatic repeating arrangements existing in each of the five colonies, Western Australia, South Australia, Victoria, New South Wales, and Queensland. There were no repeaters at Derby to admit of speaking to Wyndham or stations beyond. The conditions attending this trial were of the most favourable nature, fine weather prevailing at the two terminal stations, and the insulation being practically perfect all along the intermediate line of route.

The course of the circuit was as follows :—

Section.	Miles.	Apparatus.
Cape York (Q.) to Junction Creek ...	603	Closed circuit.
Junction Creek (Q.) to Bowen	414	"
Bowen (Q.) to Rockhampton	378	Quad.
Rockhampton (Q.) to Brisbane	493	"
Brisbane (Q.) to Sydney	665	"
Sydney (N. S. W.) to Melbourne	580	"
Melbourne (Vic.) to Adelaide	500	"
Adelaide (S.A.) to Port Lincoln	459	Duplex.
Port Lincoln (S. A.) to Eucla	606	"
Eucla (W. A.) to Israelite Bay	353	"
Israelite Bay (W. A.) to Albany	399	"
Albany (W. A.) to Perth	254	"
Perth (W. A.) to Hamlin Pool	485	Closed circuit, Toye repeaters.
Hamlin Pool (W. A.) to Roeburne ...	548	"
Roeburne (W. A.) to Derby (W. A) ...	576	"
Total	7,313	

Number of repeating stations, 14.

The working was only single, owing to simple Morse instruments being in use beyond Bowen and Hamlin Pool. Repeaters were placed on the polar side of each quadruplex used.

No. 8 iron wire used with exception of the Melbourne Adelaide section, which is No. 12 H.D.C., 5·13 ohms per mile.

The Victorian telegraphic code is used in all the colonies, except Western Australia where they use International signals. This difficulty, at first somewhat confusing, was quickly overcome by the operator at Derby adapting himself to the circumstances in using the Victorian code, whereby each listener understood what was written. This contributed in no small degree to the marked success attending the performance. It transpired afterwards that the operator at Derby had at one time been in the Victorian service.

Some little time was lost before each of the repeating stations had got a sufficiently even balance to enable the terminals to converse freely, but eventually everything went as smoothly as the most ardent operator could desire, and conversations were kept up between Cape York and Derby at the rate of from 15 to 20 words per minute. The slight delay in getting everything into proper trim was unavoidable for two reasons, firstly, on account of the necessary measurements for insulation and leakage in each section ; and secondly, owing to the working of the Zone Standard Time which came into operation in all of the Australian colonies on February 1st, 1995. Under this system, Queensland, New South Wales, and Victoria have all the same time, whilst South Australia is exactly one hour behind, with the Western Australian time one hour later than that of South Australia.

When speaking through, Cape York stated that his climate was a fine one, the temperature being almost as even in the middle of winter as in the midst of summer, and except that mosquitos, sandflies, alligators, and niggers were plentiful, there was not much excitement in his quarter. Derby replied that the heat in his portion of W. A. was mild, being about 83°, that he got P.K.'s (Cape York) signals very well, and was pleased to have spoken over such a length of line. Congratulatory messages were then transmitted to each of the Postmaster's-General, also to the various officers guiding the arrangements. A comparison of the mean time at this period resulted as follows :—

Cape York	1.48 p.m.
N. S. W. and Victoria	1.42 "
Derby	11.50 a.m.

This is not exactly in accordance with the true Zone Standard Time, but allowing for variations in the setting of the clocks, may be taken as approximately correct.

When it is taken into consideration the number of armatures that had to be attracted and released on the make and break of each signal, the many local circuits in operation, and the fact that on the Western Australian side Mr. Jenvey had to arrange impromptu repeating circuits, taking plugs out when Derby spoke and replacing immediately Cape York interrupted, the result of the experiment was eminently satisfactory to everyone concerned. It was particularly gratifying to the officers of the Victorian service who had acted on the suggestion of their electrician in making the trial, although the loyal assistance given at each of the intermediate stations was a factor greatly appreciated. There was every reason to feel gratified on the consummation of such an event, apart altogether from its public bearing. Technically considered it was a huge success, being accomplished as it was in the middle of winter ; at this period of the year in Australia the fogs are heavy and general, and the consequent leakage usually something considerable.

There is, of course, actually no limit to the distance of land line that could be covered with the assistance of automatic repeaters, given well insulated conductors and able and prompt attention at all intermediate points. So far as is known here, however, this is probably the longest stretch of land line in the world ever recorded as having been spoken over. If the Review is aware of any greater distance, its readers in Victoria would be extremely pleased to learn the particulars.

REVIEW.

Electrical Transmission and Distribution of Power. By The Electrical Company, Limited, London.

This is really a well got up catalogue and hand-book of machinery and appliances manufactured by the Allgemeine Elektricitäts Gesellschaft, Berlin, represented in this country by the Electrical Company, Limited, but it contains, in addition, some well compiled data on the advantages arising from the use of electrical power for transmission and distribution. There are in Part I., Chapter 1, some good illustrations designed to show the analogy between the transmission of power by electricity and by water, the dynamo being replaced by a centrifugal pump, the motor by a turbine, and series and parallel arrangements are thus exemplified. The term constant current dynamo, and constant current motor occurring in this part of the book and elsewhere is misleading, as in this country the term is retained for such machines as give or are supplied with a current having a constant value, continuous current being what is here referred to. Part II. is on the methods of transmission of power, and compares, first, electrical and mechanical (shafting) methods. Then (Chapter 9) follows a very thorough and careful analysis of the merits of compressed air, hydraulic, steam and electrical plant as applied to crane work, which is worth careful study.

Part IV. is a description, with numerous illustrations, of electrically driven machinery and apparatus, fans, pumps, lifts, cranes, drills, lathes, centrifugal extractors, the latter with three-phase motors, refrigerators, turn tables, mining appliances, auxiliary machines on board ship, &c.

An interesting part of this brochure is that it contains the first catalogue published in England with prices and particulars of three-phase alternating current dynamos and motors for power transmission. As it has been the habit to state that three-phase machinery is cheaper than continuous current plant of the same power, we may examine this point. The continuous current dynamos and motors are about on a par in point of price with the average of English firms, and hence a fair starting point is arrived at. On examination the three-phase dynamos prove to be slightly more expensive for equal outputs than continuous current machines, whilst with motors, up to 20 H.P. they are about on an equality ; after that the continuous current machines become cheaper. How far this is a question of patent rights or more limited market, it is difficult to say. Readers should note that the H.P. used is 75 kilogramme-metres per second = 735 watts, not the English H.P. of 746 watts. The book is got up in good style, and will no doubt serve its purpose of introducing this firm's manufactures to buyers.

CORRESPONDENCE.

Radius of Brake Strap.

The discussion on the above subject has already reached an unexpected length, and I was anticipating that your remarks on my last letter would bring it to a natural conclusion. You, however, give me a distinct challenge to point out the undeniable slips which have occurred in your remarks; and I am only too glad to accept it, hoping that the definite charges which I shall make will be either admitted, or refuted by means of distinct and logical reasoning.

Slip No. 1 occurs in your issue of August 9th, in the words, "Our remarks were not directed to deny this fact," the "fact" referred to being the statement, "where the brake strap is flexible, the centre of gravity of the weight will place itself in line with a tangent to the rim." As it stands this statement means nothing, but from the context the vertical tangent is clearly intended. This "fact" is not a fact at all, as I explained in my second letter. You subsequently attempted to get out of this error by the statement, "We could only conceive of a perfectly flexible strap being infinitely thin, and in this light alone could we allow Mr. Herbert's claim that the weight would hang immediately below the rim of the wheel." Why then did you not mention your remarkable assumption of infinite thinness? Your reproduction of my sketch, if taken as a scale drawing with a 5 feet fly-wheel, would represent a rope $4\frac{3}{4}$ inches in diameter; no mention of thickness or thinness, or any other quality except flexibility, had been made by yourselves or by me. Was the omission to mention such a startling assumption a slip, or was it intentional? I think I put the most charitable construction on it in calling it a slip.

Slip No. 2 is contained in the same article (August 9th) in the statement, "Partial flexibility will place the true radius somewhere between the rim and the middle of the rope." I do not know whether you here refer to a rope of material thickness, or to one of infinite thinness. If to the former, the statement is incorrect. Perfect flexibility would place the rope with its axis vertical. Any elasticity will, by your own showing, deflect it away from the wheel, and place the true radius outside the middle of the rope, not inside, as you state. If you refer to an infinitely thin rope, it is a slip, nevertheless, as an infinitely thin rope, with partial flexibility, is inconceivable.

Slip No. 3 occurs in the same issue, in the expression, "ropes of perfectly flexible substance perfectly elastic." The two are incompatible. A perfectly flexible rope would be one which offered no resistance to bending. A perfectly elastic rope would be one which did offer resistance to bending proportional to its modulus of elasticity, but in which there was no loss of energy by bending it. The impossible case of a zero modulus of elasticity was not in contemplation.

Slip No. 4 occurs in the same issue, in the words, "the rope hangs entirely from the rim at c by virtue of its flexibility." The load would not hang from or below c, if the rope were perfectly flexible and non-elastic, but at a position midway between b and c.

Slip No. 5 occurs in your issue of August 23rd; the expression:

$$2\pi N \{ (R + r) (W - W_1) \}$$

does not represent the "net resistance of the brake," but the energy absorbed by it in unit time.

Your statement (September 6th) that I attempted to excuse my error "on the ground that he would be right if friction were abolished, and sundry other impossibilities were created," is not a slip, but a misstatement.

Slip No. 6 (September 13th) in the words, "if, as he says, he did not mean a perfectly flexible band, why did he claim a property which could only be supposed to attach to such a band." The property I claimed could not be supposed to attach to such a band, apart from the absurd impossibility of infinite thinness, which was not in question. By "flexible band," I meant an ordinary rope, which when acted on by a heavy weight, such as ordinarily used, behaves to all intents and purposes as if perfectly flexible.

In your comments on my last letter, you attribute to me some nonsense about a jointed spring. You had spoken of a perfectly flexible brake strap of material thickness, as "altogether contrary to mechanical sense" (slip No. 7). To show that this was nothing of the kind, I instanced a chain as an example of a flexible band of material thickness, and I made no further reference to chains. You were grossly unfair in construing all the rest of my letter as referring to chains. I may remind you that you have yet to show that a rope of infinite thinness is not "opposed to mechanical sense."

You make use of the expression, "Our contention that a rope with such a tendency would help to throw a suspended weight out of the perpendicular." If the suspended weight were *in* the perpendicular, it would be at a radius $R + r$. The elastic tendency would, as shown by your sketch, throw the weight out of the perpendicular, and to a *greater* radius than $R + r$ (see my last letter). Your contention is, therefore, perfectly correct, though this is the first I have seen of it. Will you kindly state in terms as concise and free from generalities as possible, how you reconcile this "contention" with your former statement (August 9th), "partial flexibility will place the true radius somewhere between the rim and the middle of the rope," *i.e.*, at a radius *less* than $R + r$.

The ingenuity of your refined distinction between the neutral and geometrical axes of a rope inspires me with admiration. Obviously the omniscience department has returned refreshed. Your desperate attempt to use this idea as a cloak to hide all the above-mentioned glaring errors will, however, prove unavailing, as the neutral axis theory has not been brought forward before your present issue, and was evidently not in view in your former remarks on the subject, which are indeed not consistent with it.

I have said my say, and must thank you in advance for allowing me to trespass so largely on your valuable space.

E. G. Herbert.

September 14th, 1895.

[We print the above letter as the last communication on the subject. Its production has evidently given Mr. Herbert an incentive to closer reading than he gave to our original innocent remarks, the correctness of which he is so busily engaged in clouding. Like a converted sinner, however, who is always so virulent as a preacher, Mr. Herbert, in his No. 1, above, is so busy denouncing the error in his first letter, that he actually tries to make out that his error was ours. His remarks about the scale of mere sketch illustrations are on a par with the rest of his remarks, and he is as free to put just whatever construction he pleases on our omission, as we are content to leave so-called No. 1 slip to be met by the replies previously given. Mr. Herbert is one of those who, in proving a new proposition of Euclid, would want explained and proved all the foregoing propositions in place of taking them as proved.

No. 2 is hardly worth a word. Exactly where the axis of the rope may be, is dependent upon the coefficients of tension and compression. Our opinion is that most, or all, vegetable ropes will not have these coefficients equal. Certainly there is no harm in speaking of a partially flexible rope as distinct from one entirely flexible, and allowing it to have material thickness also. Perhaps it would have been better to have said partially rigid.

No. 3. We are glad to find that Mr. Herbert is beginning to perceive that it is folly to argue about perfectly flexible ropes. We did not introduce this "flexibility" into the discussion, and Mr. Herbert must wallow along with the phrase as best he may. We can only add that the expression here found fault with was used simply to illustrate Mr. Herbert's own impossible claims, and to try and show him his error.

No. 4. If the rope were *perfectly* flexible, it would be infinitely thin. Our correspondent is getting mixed once more, and is separating words from their context in an unjustifiable manner.

No. 5 shows how pedantic a man can be when he is bent that way. Mr. Herbert's a, b, c of mechanics perhaps taught him to use a set phrase. Our own less pedantic expression, though perfectly correct, and conveying a correct meaning, does not meet his views, and therefore is classed as a slip.

No. 6. We have no need to add more to what we have already said on this point. If he meant an ordinary rope, why did he claim for it a property it did not possess, to wit, the power of being extended and compressed along its inside circumference at one and the same time?

No. 7. Finally, his proposition that a chain is a flexible band of material thickness is mechanical nonsense. A chain, if we eliminate the effects of friction by vibration, bent round a wheel, becomes virtually a linear rib, the line of pressure (slip No. 8, tension please) passing through the pins or other points of link contact. The material beyond this linear rib has absolutely no effect. It is as though one cut partly through a bar with a series of saw cuts. The cut portion loses its effect in rendering the bar rigid, a band of infinite thinness is certainly not a mechanical possibility otherwise, nor did we say it was. It is the only band, however, that fills Mr. Herbert's ideal as set forth in his first letter, to which we hope anyone interested in the question will refer.

The final question as to the quantity, $R + r$, will be obvious to any ordinarily sensible man as dependent entirely on the position of the neutral axis of the rope and the stiffness of it as a coiled spring, and while, as we said, the one may bring the $R + r$ within the geometrical axis, the other may more than counteract this. Note how Mr. Herbert wishes here to tie us down to an absolute statement of the exact result which is dependent on the radius of the wheel, the rope thickness, the weight and the material of the rope, and its mode of manufacture. He wants to pin us to an exact statement of the results of all these factors, and immediately afterwards has a sneer because we differentiated between the neutral and geometrical axes of the rope, and he quarrels with the use of the neutral axis because, forsooth, we did not, in our remarks as far back as August 9th, publish a glossary of the terms to which we should confine ourselves.

We leave the matter here. It has already occupied more space than it deserves, and in publishing the above, we do so simply because Mr. Herbert appears to think his retreat from his "unanswerable" first letter had better be accompanied by a song of triumph. In none of his above "seven slips" has he taken a fair stand, and we would only ask those interested to read them with the respective numbers before them.

We still think our correspondent would have best consulted his own good by a square admission of error, in preference to a dragging out of the subject, with no other object than to catch us tripping and obscure the true issue, viz., the correct radius at which to measure a friction brake strap. This we agreed should practically be at the mid-thickness of the rope. Our two critics both admit this now, but while *Lightning* denies that it ever doubted it, Mr. Herbert wants to complain that we have beaten him with a badly trimmed stick instead of using a smooth cane.—Eds. Elec. Rev.]

Working Expenses of Electric Railways.

I notice that in your issue of the 13th inst., under this heading, you state on page 309: "Twelve months ago we spoke of the lamentable career of the secondary battery on this line."

In reply to your remarks I wish to state that about 14 months ago my company supplied their first traction battery to the Birmingham Tramways Company, and that the number of our batteries at work on the line was gradually increased; and that for the last six months the Bristol Road line has been run entirely by chloride batteries.

My company has for the last 9 or 10 months supplied such batteries as are necessary to work the line at a given rate per mile; this rate being considerably less than the cost formerly incurred by the tramways company for the purchase and up-keep of batteries.

The increased working expenses of the line are therefore in no way due to the increased cost of batteries per mile. The staff required for the superintendence of the chloride protected cells is also considerably less than that required for the open type batteries formerly employed.

You will see from the above that you have spoken without due knowledge of facts, and have evidently drawn your conclusions from published figures which, without the knowledge as to how they are made up, do not give the necessary information.

H. A. Earle.

Ipswich, *September 14th.*

[The article containing the remark to which our correspondent objects was reproduced from the *Railway World*.—Eds. Elec. Rev.]

Electric Lighting of a Great City.

In your correspondence with Sir David Salomons on the "Electric Lighting of a Great City," might I enquire whether you are absolutely correct in saying that the armature coils are subject to a stress in one direction only, due to the field. Is this not true only when the armature current is either *in*, or in *directly opposite* phase with the induction?

Some time ago I noticed that a lamp filament, with an alternating current passing through it, held close to the end of an open cored choking coil fed in parallel from the same mains, vibrated in the same way as in a steady field. Is it not possible that vibration, both in the armature coils and the filament, is due to the difference in phase between current and induction?

A. E. M.

Bedford, *September 17th*, 1895.

[Certainly. The case you cite is an illustration of what occurs in some alternators under certain conditions.—Eds. Elec. Rev.]

In your issue for September 6th, p. 279, you have made a statement which does not "run well in parallel" with p. 638 of Dr. S. P. Thompson's book on "Dynamo Machinery."

Referring to Sir D. Salomon's remarks on the construction of alternators, you say that the vibration in alternator coils is only imaginary because that, in a good machine, the direction of the current changes as the conductor passes from pole to pole, and the stress is consequently in one direction.

I gather from Dr. Thompson's remarks that this is only true when there is absolutely no "lag" or "lead" of current. He shows very clearly, I think, that if there is some self-induction, then each coil as it passes away from its pole acts as a motor coil and receives a thrust forward, causing a racking action. If self-induction was absent the current, of course, would reverse without this action.

I would be glad of correction if in error.

T. R. K.

September 10th, 1895.

[A reply to this letter will be found in our Leader columns.—Eds. Elec. Rev.]

Iron Losses in Transformers.

In reference to the letters which have appeared on this subject, and in connection with which my name has been mentioned, I do not think Mr. Adams has done much to enlighten the student in question. The date of the test does not affect the truth of the observation, and the fact remains that the iron losses due to hysteresis varies with the quality of the iron to a far greater extent than shown in the comparative curves published in your issue of August 23rd. In my book I stated that the curve was "for a fairly good sample of iron," but not the best obtainable. As I made, while acting as Mr. Kapp's assistant, the tests of transformers from which the results were obtained, both for the curve published by me and by Mr. Kapp, I can vouch for the accuracy of the two curves. In transformer design no finality has been obtained up to the present in the direction of uniformity of the magnetic properties of the iron plates, although certain iron makers now guarantee their production within certain limits.

R. W. Weekes.

Charlton.

BUSINESS NOTICES, &c.

Ayrton & Mather's Electrostatic Voltmeters.—We have now before us a complete copy of Mr. R. W. Paul's catalogue of electrical instruments, the advance sheets for which we noticed a few weeks ago. There is described, on pages 53 and 54, the Ayrton and Mather's patent standard electrostatic gravity voltmeter for direct or alternating pressures of any frequency. An adjustable index is provided for indicating the working pressure, as shown in fig. 1. The conductors are shaped into parts of cylinders. The controlling force is gravity, acting on a weight attached to the needle. The advantages claimed for the form of needle used over those consisting of flat plates are greater strength and lightness, less moment of inertia, and greater aperiodicity or dead-beatness. The arms of the needle being in one piece with the curved portions, electric resistance, so serious with rapid alternations, is avoided. The

working parts are shaped so as to give the scale equal divisions, or to spread it out at a desired portion of the range. Dead-beatness is secured by an improvement recently made in these instruments, and shown in fig. 2. A strong permanent magnet is fixed to the casting carrying the needle, and provided with a soft iron pole-piece. A copper sector, which balances the needle, swings between the poles of this magnet, and damps the motions by the action of the Foucault currents generated in it. A separate index is provided, and is set by means of the crown wheel and pinion at the top of the instrument.

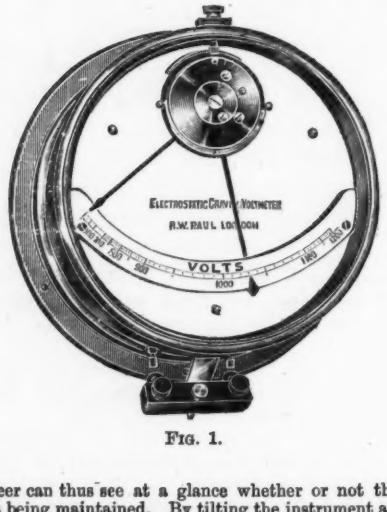


Fig. 1.

The engineer can thus see at a glance whether or not the working pressure is being maintained. By tilting the instrument and turning the index as far as it will go towards zero, the needle may be clamped for travelling. The case is entirely insulated from the working parts. The pointer is not affected by rubbing the glass, as the latter is coated with a transparent conducting varnish, invented by Prof. Ayrton and Mr. Mather. The terminals are embedded in a block of ebonite,

Fig. 2.

hinged to the case, and provided with ebonite-headed screws. No metal parts are exposed to the touch. Fuses are provided, and enclosed in glass tubes with brass caps; they are placed in ebonite tubes, projecting into the instrument, and making contact with the working parts. They may be removed by unscrewing the screw securing the terminal block (in which the fuses make contact in the normal position). A spark gap is provided inside the instrument, and adjusted to allow the passage of a spark should the potential rise to double the working pressure. This prevents sparking between the working parts, which are tested to more than double the normal pressure. On a spark passing at the gap, the fuses are blown, thus cutting the instrument out of circuit.

Bankruptcy Proceedings.—First meetings of creditors and contributors in *re* Ronald A. Scott are announced for September 24th, at 2 and 2.30 p.m. respectively, at 88, Temple Chambers, Temple Avenue, E.C.

Business Announcement.—We are informed that by mutual friendly agreement, Mr. S. B. Tatham retired from his partnership in the firm of Girdlestone, Tatham & Co., on August 31st last; by arrangement his services have been retained, and he will be employed in the interests of the firm as heretofore. The remaining partners will carry on the business under the style and title of Girdlestone & Co.

Catalogue.—Messrs. Caddy & Co., Limited, of Daybrook, Notts, have sent us a copy of their catalogue of rocking, stationary and forced draught furnaces, fitted with their tubular fire bars to suit all classes of coal. The catalogue opens with a few words about fire-bars, includes a number of photographs of the works and of the officers of the company, and a large number of testimonials. Mr. Leoline Edwards is engineer and manager to the company.

Dissolution of Partnership.—The partnership heretofore subsisting between W. Jeffery & F. Taylor, carrying on business as electrical engineers at 11, Queen Victoria Street, E.C., as Jeffery, Taylor & Co., has been dissolved by mutual consent, as and from August 1st, 1895. All debts will be received and paid by W. Jeffery, who will carry on the business under the present style or firm of Jeffery, Taylor & Co.

Electrical Switches.—We are informed that the General Electric Company, Limited, who are the owners of Patent, No. 3,664, dated February 28th, 1891, and entitled "Improvements in Electrical Switches," have granted licenses for the manufacture and sale of the well-known switches called "Tumbler" or "Link" switches (with either a link movement or a heel piece) to the following firms:—The Edison & Swan United Electric Light Company, Messrs. Evered and Co., Limited, of London and Birmingham, Messrs. McGeoch and Co., of London and Glasgow, Messrs. Verity & Sons, of London and Birmingham, Messrs. Bayley Bros., of Walsall, and Messrs. Tucker and Co., of Birmingham. The names of any further licensees will be published in due course. Buyers of Link switches should note this.

Fire.—A small fire occurred on 12th inst. at 36 Wharf, Graham Street, City Road, on the premises of the Brush Electrical Engineering Company.

Liquidation.—Mr. Wm. Wing, of 7, North Church Street, Sheffield, has been appointed liquidator of F. Marten Hale and Co., Limited, armoured cable and hose manufacturers, of Emerson Street, Southwark, London. A receiver has also been appointed on behalf of the debenture-holders.

Tunbridge Wells.—We hear that Messrs. Gilbert & Co., of Kensington, have obtained the order for fitting St. Mark's Church, Tunbridge Wells, for the electric light.

ELECTRIC LIGHTING NOTES.

Ayr.—£5,000 more is to be borrowed for electric lighting purposes.

Balmain (Australia).—The Council contemplates adopting electric lighting for the borough. At present, £2,600 per annum is paid for gas. It is estimated that an electric light installation will cost £12,000, with annual working expenses £1,700.

Battersea.—The Special Committee have presented a report *re* electric lighting, in which they state that, after due inquiry and consultation with Dr. J. Hopkinson, F.R.S., they are not prepared to recommend the adoption of a scheme for utilising the dust destructor in connection with the electric light. After careful consideration, they have resolved to invite competitive schemes for lighting the parish, and to offer premiums for the three best.

Belfast.—The electrical engineer is to obtain estimates for the provision of additional engines for the central station.

Bootle.—The Watch Committee have an electric lighting scheme under consideration.

Bath.—The City Council, on 17th inst., decided to make application for a provisional order.

Blackburn.—Tenders are in for wiring and fitting the Town Hall. Some of the tenderers have been asked to furnish designs for fittings, among them being a local firm whose tender amounted to £908.

The proposed extensions, to which we referred last week, are to be carried out and tenders are to be obtained.

Cowes, I.W.—For the supply and fixing of electric lighting plant for the Cowes Town Council, for which Mr. N. F. Dennis, A.M.I.C.E., is the electrical engineer, the following firms tendered:—Messrs. Siemens Bros., Messrs. Greenwood & Batley, Messrs. John Fowler & Co., Messrs. Thomas Parker, Limited, Messrs. Johnson & Phillips, India-Rubber and Gutta-Percha Company, Messrs. Bennett & Druce, and the Brush Electrical Engineering Company. Messrs. Crompton & Co., Chelmsford and London, £6,215; Messrs. Sharp & Kent, London, £5,333; Electric Construction Company, Wolverhampton, £5,154 18s. The last three low tension schemes are retained for detailed analysis.

East Grinstead.—Messrs. Owen, Lucas & Pyke has written to the Council in reference to the proposed electric light installation, asking for an interview, as they desired to get to work at once and have the lighting station established before the winter.

A letter from Messrs. Petit & Hards asking to be allowed to give an estimate for the electric light of the workhouse, was ordered to be placed on the table.

Halstead.—The District Council is to consider the lighting question, with special reference to the merits of gas and electricity.

Kettering.—A committee of the Council has been appointed to consider the electric lighting question, with power to call in expert opinion.

Kingstown.—The Township Board is applying for a provisional order to keep the electric lighting powers in its own hands.

London, E.C.—The Great Synagogue in St. James's Place, Aldgate, E.C., is now lighted by electricity.—One 36-light and six 24-light candelabra are used in the body; 21 6-light candelabra in and under galleries; 20 1-light brackets under galleries; two 3-light standards at each end of synagogue; four 1-light standards by ark; six 1-light standards on reading desk; and four 1-light in ark. These make a total of 352 lights, of which 318 are candle lamps, and 34 8 and 16-C.P. ordinary lamps. There are also 23 16-C.P. lamps to light entrances, staircases and offices. The building is over 100 years old, and the candelabra, which are very fine specimens of brass work, cannot be very much less. The whole of the work has been carried out by Messrs. D. Hulett & Co., Limited; engineer (Mr. A. R. Pond), under the direction of Mr. Lewis Solomons, of 55, New Broad Street, E.C. Current was used on September 6th for the first time.

Llanelly.—Messrs. J. C. Howell & Co., Limited, want either to purchase the Council's provisional order, or to apply for one themselves. The Council are considering the matter.

Rockhampton (Queensland).—From the extracts from the report of the Rockhampton Gas and Coke Company, Limited, in our "City Notes" columns, it will be seen that Mr. E. F. J. Hewlett, who was for some years connected with electrical firms in this country, has been appointed electrical engineer from a large number of applicants.

South America.—The *Financial News* correspondent says that the Mayor of Buenos Ayres forwarded to the City Council a proposal for the establishment of three electric light stations, in Calles 60 A, Cordoba, and Caseros, for lighting the streets. The cost of the installation is estimated at $346,929 gold and $125,280 national money. The Public Works Committee disapproved of the scheme, and proposed that the Director of Public Lighting be sent to Europe and the United States to investigate and study the systems of electric street lighting in vogue in the various cities. The Committee of Interpretation are of opinion that the Mayor's proposition should be approved.

Switzerland.—It is proposed to put down plant for the electric lighting of the villages of Stalden, Kreuzstrasse, and Oberdressbach (Berne). A central station is in course of construction at Soleure. The contract for the supply of the transformers, and the supply and laying of the necessary conductors, has been secured by Messrs. Alioth & Co., of Basle. A central station has just been completed and put in operation at Wattuze (St. Gall). The dynamos are driven by two turbines supplied by Messrs. Escher, Wyss and Co., of Zurich. A petroleum engine has also been put down as a reserve in case of failure of the water supply. A central station is in course of construction at Altdorf (Uri).

Tottington, Lancs.—Messrs. S. H. Heywood, of Brazenose Street, Manchester, have received the contract for erecting an arc lighting installation at the mills of Messrs. S. Knowles & Co., Limited, printers, &c., of Tottington, the work being carried out in accordance with plans and specifications of Mr. Walter Leake, consulting engineer, of Manchester.

Wakefield.—We learn that the tenders for the electricity supply works were opened on Thursday last week by the Electric Lighting Committee, and are now being analysed by Mr. R. Hammond. They number 49.

Yarmouth.—The electric light undertaking showed a profit for the month of August. The surveyor's monthly statement shows: Income, £162 7s. 8d.; expenditure, £108 18s. 9d.

ELECTRIC TRACTION AND MOTIVE POWER NOTES.

Baltimore Electric Locomotives.—The *Financial News* last week said:—"Accounts are still conflicting as to the working of the experimental trolley electric locomotive in the Baltimore and Ohio tunnel at Baltimore. Some days reports are favourable and on other days difficulties are met."

Blackburn Tramways.—The Blackburn Corporation Tramways Company, Limited, have written to the Council stating that the company had been considering the question of working the Preston New Road and Cemetery sections of the tramways with electric traction, and that Mr. E. M. Lacey had prepared a report on the matter from which it appeared the tramways could be worked cheaper by this method; also stating that the company had not the necessary capital to carry out the scheme, and asking if the Corporation would consider the question of providing necessary capital for carrying out the scheme; and, if so, upon what terms. A committee is considering the matter.

Dublin Electrical Tramways.—The first consignment of the new electric cars to be used on this system have arrived at the Depôt, Ballsbridge, from England.

Owing to the decision of Mr. Justice Murphy on Tuesday last week on the application made by the Pembroke Commissioners for an injunction against the Dublin Southern Tramways Company, work has been resumed by the latter in laying the new electric line through the Pembroke township. The Commissioners are, by the judge's decision, referred to their rights under the Act of Parliament authorising the construction of the line; if they consider that they sustain any special damage by the manner in which the line is constructed they will appeal to the court, who will thereupon decide whether their complaint is well founded. But the works must now proceed without further hindrance. There will be altogether 20 motor carriages, and a like number of passenger carriages. Each of the motor carriages can accommodate 60 passengers, and each of the others 40, so that 100 passengers can be carried on each journey. The journeys will be at intervals of 10 minutes, so that a very full passenger service will be supplied. It is expected that the completed line will be ready for inspection by the Board of Trade representative early in October, and that the line will be open for traffic about the middle of that month.

Electric Traction in France.—An application has been made and favourably received for a concession to construct and operate an electric tramway between Viricel-Chazelles and Saint Lymphorien-sui-Coise (Loire). A company has just been formed in Paris, with a capital of £120,000, to be known as the Compagnie Nouvelle d'Electricité, to construct and operate electric tramways on the Siemens system in France.

Electric Traction in Switzerland.—A system of electric tramways is about to be constructed in Lausanne. The electrical plant will be supplied by the Société de l'Industrie Electrique of Geneva, the cables by Messrs. Berthoud, Borel & Co., of Cortaillod, while the rolling stock will be supplied by the Neuhausen Waggon Works. It is proposed to continue the Bremgarten-Wohlen electric tramway as far as Fahrwangen.

TELEGRAPH AND TELEPHONE NOTES.

Exports of Telegraph Wire and Apparatus.—The quietness which is this year ruling in the export trade of this country in telegraph wire and apparatus connected therewith was more pronounced than ever during last month, as according to the returns which are now available, the exports during August only amounted to £29,448, as compared with £67,550 in the corresponding month of last year, and £176,859 in August, 1893. The returns for the first eight months of the year illustrate strikingly the depression in this branch of trade, the exports during that period only amounting to £338,169, as compared with £1,254,774 in the corresponding period of last year, and £733,359 in the first eight months of 1893.

Personal.—Mr. J. Schneider left England yesterday for Buenos Ayres, to take up the double appointment of Inspector of the Central and South American Cable Company's aerial line system from Buenos Ayres northward, and of assistant electrician of that company. Mr. Schneider was for many years associated with the Silvertown Company, and has been prominently connected with numerous cable-laying and repairing expeditions on the West Coast of Africa, in the Brazils, in Chili, Peru, and Central America. His friends will congratulate and wish him all prosperity in his present work, upon which he brings so much practical experience to bear.

Proposed American Cable to Hawaii.—A despatch just received on this side states that, according to arrangements recently entered into between an American sugar planter and the Hawaiian Government, a contract has been signed granting an annual subsidy of $40,000, with an exclusive right for 20 years to land a cable from the American Continent only to Hawaii. By this arrangement, which has been ratified by the legislative of the Republic, the Hawaiian Government bind themselves not to permit the landing of any other cable on the Hawaiian group. The contractors, however, make it conditional that the line will not be constructed until an annual subsidy of $175,000 has been arranged with the United States Government. According to the contract the line must be commenced in May, 1897, and completed in November, 1898. The negotiations for the contract were conducted with the Hawaiian Republic with the greatest secrecy, and, on it becoming known that it was signed, a meeting of the Honolulu Chamber of Commerce was immediately called, at which the British and German members protested against the granting of any exclusive right, as it would preclude the construction of an English, German, or French Pacific cable for the next 20 years, the Hawaiian group being the only islands in the North Pacific affording a landing place for such a long cable.

Russia and the Overland Telegraph Route to India.—The following extract from a contemporary is of great interest, as showing the increasing difficulties which are met with by telegraph lines passing through countries which are not subject to the Imperial Government. As the line in question carries a very large proportion of the traffic between India and the United Kingdom, the threatened change in the working arrangements will doubtless arrest the attention of the telegraphing public. Our contemporary says:—"The Russian Telegraphic Administration has informed the directors of the Indo-European Telegraph Company, Limited, that the latter will not in future be permitted to fill up vacancies which occur in the company's Russian stations with English operators; telegraphists from

the Russian service are to be recruited for this purpose. In the interests of the Anglo-Indian commercial public who so largely utilise this splendidly worked trans-Continental system, it is to be hoped that the managing director of the company will prevail upon the Russian Administration to rescind this high-handed order. Russian telegraphists are utterly incapable of working this important line with the speed and accuracy of the home trained and picked staff now employed. The Indo-European line enters Russia at the western frontier station of Alexandrovo, near Thorn, and after traversing Warsaw, Rovno, Odessa, Kertch, Soukhoum and Tiflis, passes into Persia, at the frontier point of Djulfa. Odessa and Warsaw are the transmitting stations in Russia, the others being relay stations only. Notwithstanding the increasingly heavy traffic over the Indo-European line, the average time occupied in the transmission of telegrams between London and Calcutta, and *vice versa*, is 50 minutes, which is undeniably a splendid standing record."

The Reduction of Telegraph Rates to the East.—We learn that letters have been received by the Chambers of Commerce of Glasgow and Dublin, in which their co-operation is invited by the London Chamber of Commerce in such measures as may be found desirable to secure an adequate reduction in the cost of telegrams between this country, India, and the East. This movement seems natural, when we remember that the present rate to India remains fixed at 4s. per word, whereas the rate to Australia has been reduced to 4s. 9d. per word; a reduction which was effected under a colonial guarantee. We now gather from the Australian Press that "the result of the year's work has been so satisfactory that the guarantee to the Eastern Extension Company has been more than covered, and none of the colonies will now have to pay anything under it." When it is borne in mind that, besides this satisfactory state of affairs, it was announced at the Hobart Conference a few months ago, "that the saving already effected to the customers of the cable by the reduced rates amounted to £200,000," it is not at all surprising that Indian commerce should ask for a reduction proportional to that obtained by Australia with such gratifying results.

The Amazon Cable.—Although, according to the contract, this cable need not be laid before March next, the intention, if possible, is to lay it by Christmas. The *Faraday* will load and take out this cable upon her return from the Atlantic, where she is now engaged in repairing the main section of the French company's cable.

Telegraphic Communication between the Channel Islands.—The inhabitants of Guernsey and Sark have long desired that the two islands should be in full telegraphic communication with each other. A petition, signed by over 1,000 persons, has been forwarded—through the Lieutenant-Governor of Guernsey—to the Postmaster-General, requesting that a cable be laid down, and, in the meantime, a military heliographic system has been established, and is in great demand. It is worked from the Mill, at Sark, to Fort George, Guernsey, and *vice versa*; and soldiers deliver the despatches.

CONTRACTS OPEN AND CLOSED.

OPEN.

Ashton-under-Lyne.—Tenders are invited for an electric light installation for Wagstaffe's Steam Preserve Works, Hurst Brook, Ashton-under-Lyne.

Banstead and Colney Hatch.—September 30th. The Asylums Committee of the London County Council is inviting tenders for various works in connection with certain temporary iron structures which are to be erected for them. The list includes a fire alarm and telephone system, also heating arrangements at their asylums at Banstead and Colney Hatch. Particulars from R. W. Partridge, Clerk of the Asylums Committee, 21, Whitehall Place, S.W.

Belfast.—September 28th. Tenders are invited for the supply and erection of two direct-coupled steam engines and dynamos, battery of accumulators, main switchboard, and installation of about 232 incandescent lamps, complete, for the lighting of Belfast Lunatic Asylum, for the Commissioners for the Control. Particulars from Mr. O. A. H. M'Cowen, Chapel Lane, Belfast.

Belgium.—October 10th. The municipal authorities of Tongres are inviting tenders for the concession for the public and private electric lighting of the town. Tenders are to be addressed to the Administration Communale, Tongres, Belgium.

Blackburn.—The Corporation invite tenders for electric lighting cables and accessories. Further particulars will be found in our advertisement supplement.

Braila.—October 2nd. The details regarding the tenders invited for electric tramways and lighting the city for the Municipal Authorities of Braila were given in our issue for August 30th.

Dewsbury.—September 21st. Tenders are invited for the wiring of the public baths and library, for the Corporation. Details from the Borough Electrical Engineer, Electricity Offices, Bradford Road.

Dublin.—Messrs. Goodbody & Co., want tenders for an electric lighting installation. Further particulars will be found in our advertisement supplement.

Dundalk.—October 7th. The Town Commissioners invite tenders for an electric lighting installation.

France.—Tenders are being invited for the supply of a regular current of electrical energy for an installation of about 1,200 lamps. Tenders to be sent to M. le Directeur du Grand Cercle, Aix-les-Bains (Savoie), France.

Gravesend.—September 20th. Tenders are invited for supplying a telephone, and providing, delivering, and fixing, &c., the necessary poles, wires, instruments, &c., for a line from the sanatorium to the office of the sanitary inspector and the police station, for the town council. Particulars can be obtained of the sanitary inspector, Town Hall.

Germany.—September 21st. The construction of an electric local railway between Bonn and Königswinter or Honnef has been practically decided upon at the joint cost of the local authorities of Obercassel, Oberdollerndorf, Niederdollerndorf, Königswinter and Vilich. The last named body is inviting firms to submit plans, &c., for the projected line before the 21st inst. The firm whose project is accepted will be entrusted with the construction and working of the line. Projects and plans are to be sent to the Burgmeisterei, Vilich, Germany.

Harrogate.—The Corporation invite tenders for the supply and erection of plant, including boilers, alternators, switchboards, transformers, meters, and overhead travelling crane for electric lighting installation. Further details may be found in our advertisement supplement.

Harrogate.—September 30th. Tenders are invited by the Corporation for wiring the new Montpellier Baths for electric lighting. For further details see our advertisement supplement.

High Wycombe.—October 14th. The Chepping Wycombe Urban Sanitary authority invite tenders for working the electric lighting provisional order obtained by them within the borough, for a term of years and upon approved conditions. Tenders to be delivered to the Town Clerk, High Wycombe, from whom further details may be obtained.

Leeds.—September 24th. Tenders are invited for providing and fixing several new lightning conductors, and for repairing others, upon and at the workhouse premises in Beckett Street for the Guardians. Particulars at the offices.

London, W.—October 7th. Tenders are invited for the supply of stores from November 1st to October 31st, 1896, for the Great Western Railway Company. The following are some of the items: (9) Acids, alkalies, &c.; (10) oils, turpentine, &c.; (17) India-rubber goods; (18) telegraph instruments; (19) telegraph apparatus; (20) copper wire, G.P. wire, &c.; (21) telegraph ironwork and tools; (22) telegraph drysalteries; (23) carbons for electric light; (24) zinc, antimony, copper pipes, brass, &c.; (31) cast-iron pipes and rain-water goods; (40) tubes, iron and steel: (47) telegraph poles and yellow pine. Samples and patterns may be seen on and after 23rd inst. at the office of the Stores Superintendent, Paddington Station.

Manchester.—September 20th. The Corporation invite tenders for the supply of about 15 tons of copper strip. Further particulars will be found in our advertisement pages.

Rangoon.—November 4th. The Municipal Committee is inviting tenders for electric lighting. Particulars to be obtained from Messrs. Ogilvy, Gillanders & Co., 67, Cornhill, E.C.

Roumania.—October 2nd. The municipal authorities of Braila, Roumania, are inviting tenders until October 2nd next for the concession for (*a*) lighting about 64 kilometres of public streets by both gas and electricity, and (*b*) 64 kilometres of public streets by electricity alone. They are also inviting tenders for the concession for the construction and operation of a network of electric tramways in the principal thoroughfares of the town. Tenders to the Maire, Hotel de Ville, Braila.

Vienna.—November 14th. The Municipality of Vienna asks for tenders and plans for the construction and working of electric railways in and around the city. The notice may be seen at the Commercial Department of the Foreign Office.

CLOSED.

Ayr.—The tender of Messrs. W. S. Higg & Co. has been accepted by the Town Council for the electric wiring, and that of Messrs. B. Verity & Co., London, for the fittings required by the new electric installation (Municipal Buildings?) for the Town Council.

Bedford.—The following tenders were sent in to the urban sanitary authority for the supply of vulcanised rubber cables:—

Telegraph Manufacturing Company, Ltd. ...	£2,582 6 8
Siemens Bros. & Co., Ltd.	2,158 12 11
W. T. Glover & Co.	2,131 7 1
The India-Rubber, Gutta-Percha, and Telegraph Works Company, Ltd.	2,077 16 4
W. T. Henley's Telegraph Works Company, Ltd. (accepted)	1,797 13 3

London, W.C.—For carrying out the work required in supplying and fixing wires, cables, and fittings for the installation of the electric light at their board-room and offices, 57, Broad Street, W.C., the Guardians of St. Giles and Bloomsbury have accepted the tender of the Brush Electrical Engineering Company.

Portsmouth.—The contract for the wiring of the Buckland, Southsea, Portsmouth and Portsea Police Stations for electric lighting has been given to Messrs. Newton & Co., of London.

Taunton.—The Town Council has accepted the tender of the British Thomson-Houston Company, Limited, £1,058, for supplying an alternator and engine.

Yarmouth.—Last week the Council accepted the tender of the British Insulated Wire Company, at £1,031 1s., for the new cable, including laying and jointing, that being the lowest tender received. Tenders for the supply of transformers were also received, and the Council accepted that of Messrs. Crompton, being the lowest received, as follows:—1 kilowatt, £9; 2 ditto, £12 15s. 6d.; 5 ditto, £19 10s.; 10 ditto, £31 15s.; 15 ditto, £42 2s 6d.; 25 ditto, £59 11s.

NOTES.

The Poor Locomotive.—We fear that the many ignorant comments of self-styled electricians upon the coming end of steam traction will do no good to the electrical cause. Its immediate effect is to rouse comments such as one in the current issue of *Machinery* of New York, which calls attention to the nonsense poured out in connection with the Baldwin-Westinghouse arrangement. *Machinery* has no doubts as to the economy of electricity on lines of frequent service for surburban traffic, but seriously doubts its applicability to lines even 90 miles in length, such as the New York and Philadelphia division where immense power houses at more or less frequent intervals must be built, each capable of fulfilling the duties of the next station in case of breakdown. *Machinery* says: "It is an open secret that one of the largest elevated railroads in the world would willingly pay several per cent. more for cost of operation by electricity if results could be guaranteed. For elevated railway work where the current is so easily and safely carried we should think that there is experience enough available to give a fair guaranty of performance. There is far too much popular writing about electricity. The average pressman sees an electrical car and he sees no more. His knowledge of why it moves is about level with the appreciation of a sailing ship by a man who has no knowledge of the existence of wind, and half the people who bleat about the "new force" don't know that there is a steam engine behind the scenes, and that electricity is but a substitute for a running cable. If electricians would cease talking about main line traction it would be a good thing. The Baltimore experiment alone is sufficient to condemn the use of electrical locomotives for main line work at present, for such is the faith in the new locomotive that it has been made to weigh 90 tons, and powerful enough to pull two ordinary steam locomotives helplessly about. When we see a bridge over-proportioned, or anything else much too large for its duty, is it not usually true that there is a lack of faith in some detail? The Baltimore experiment is perfectly good and in place, but its very carrying out on certain lines is enough to show that its constructors are not losing their heads in anticipation of displacing steam locomotives. They have got to carry out certain work and have taken care that, if they can help it, there shall be no failure. For ourselves we shall advocate no main line electrical traction for the present. Let the branch lines and feeder lines be attended to; there is the field for electricity for years to come.

Another Unfortunate Inventor.—In the department of Jura, in the east of France, died, at the commencement of the present month, aged 84, the proprietor of a *Bureau de Tabac*, who, in his time, had been a hard working country doctor, and a man of some note in chemical and physical science. This man, Dr. Sauria, is said to be the first inventor of lucifer matches. In 1831 he was a pupil at the College of Dôle, and the idea then occurred to him of superseding the *briquet*, or tinder-box, by a friction match, made by glueing a mixture of chlorate of potash, phosphorous and sulphur, on to the end of a slip of wood. The young student had not the means to patent the invention, but showed it to M. Nicolet, the professor of Physics at Dôle. On the occasion of a visit to Germany, it appears that the professor mentioned, in the course of a lecture, that a light, or, as they say in France, *du feu*, could readily be obtained by the above means. The practical and enterprising Germans soon set about manufacturing the friction matches, which, under the name of *allemandes*, were imported into France, and found their way to Dôle.

Alternating Current Supply.—About a year ago a discussion ran through several issues of the Review on the action of alternating currents upon dielectrics. We there expressed the opinion, founded upon personal experience of both alternating and direct current cable networks, that the insulation required for an alternating cable was necessarily thicker for a given factor of safety, using the same effective pressure in each case. Since these remarks appeared little or no evidence has been published to controvert our argument, and such experience as has been gained in the intervening 12 months seems to support the statements then made. Dr. Fleming has lent his name to the statement, as issued by the vendors of okonite cable, that he "found the lowest quality of this insulation would stand, when under water, a pressure of 5,000 volts alternating current = 7,000 volts direct current, without any signs of breaking down, the cables having been immersed from 15 to 20 days." In conversation with an electrical engineer of 14 years' experience, largely on alternating current central station work, we casually asked him if he considered that the insulation should be thicker on a cable for alternating current use than on one intended for direct currents, the effective difference of potential being the same in each case, and he replied in the affirmative without hesitation. Mr. Crompton also happens to have referred to the subject recently, for in an interview with the representive of a contemporary he is reported to have said: "The cost of insulation for the same mean pressure is clearly greater in the case of alternating transmission, for the maximum pressure has to be provided for, against which cost is to be set off the cost of commutators and of running machines in series if continuous current be used," *i.e.*, for large power transmission schemes. There is, therefore, a sufficient divergence of opinion on the matter to make it advisable to treat our view as the correct one, even if it be not accepted that our contention has been fully proven. Considerations of prudence will lead it to be taken as a working hypothesis, until at least it is disproved by properly accredited experiments or the accumulation of actual experience.

Postal and Telegraphic Conference.—The report of the proceedings of the Postal and Telegraphic Conference, held during the present year at Hobart, South Australia, has recently been issued. The following were the principal resolutions adopted relating to telegraphic and electrical matters:—*Telegraphic Service—Pacific Cable.*—This Conference re-affirms the desirableness of the construction of a Pacific cable to connect the Australasian Colonies and Canada, and in view of the ascertained practicability of the scheme, respectfully urges upon the various Colonial Governments that steps be taken for the furtherance of the project at the earliest opportunity. *Cable Guarantees.*—That the several Colonies agree to guarantee international revenue to the Eastern Extension Telegraph Company of £227,000 per year, and to make up any loss below that amount, provided the total payment in any one year shall not exceed £10,000, and to guarantee a revenue of £20,000 on the New Zealand cable, and to make up any loss below that sum, provided the payment in any one year shall not exceed £9,000; provided always that rates not higher than those now ruling be charged by the Eastern Extension Telegraph Company during currency of such guarantee—such arrangement to be for a fixed period of five years. *Telegraph Service.*—On the subject of precedence of Press cable messages, this Conference resolved: "That the Governments concerned be urged to take steps to obviate, as far as possible, the inconvenience caused to the mercantile community by delay in forwarding private messages in case of telegraphic interruption." *Electrical.*—That the second report of the Committee appointed at the Postal and Telegraphic Conference held at Hobart, 1892, for the purpose of drafting a code of rules and regulations for the erection and laying of electric light and power wires, be adopted by this Conference.

King's College.—Prof. Banister Fletcher, F.R.I.B.A., has sent us a copy of the syllabus of the Architectural Curriculum, 1895-6 Session at King's College, London. Day and evening classes in architecture and building construction are held. There are also reference museums and a library in connection therewith.

Platinum and its Supply.—The following is from our contemporary *Invention* :—

It is to be hoped that the world's supply of platinum will be reinforced by new discoveries of this metal. It is almost a necessity in many sorts of electrical work, for which no satisfactory substitute has been found, while the supply is certainly not commensurate to the demand, and the price is constantly appreciating. Some hopes were excited that the black sands of the Oregon beaches, in the United States, would become contributors of this metal, but the investigations of the United States Geological Survey have proved disappointing. A scarcely appreciable amount of platinum was found, although the sand contains about 1·5 dwt. of gold per ton. The entire platinum output of the Ural Basin has been sold at very high prices for 10 years ahead. But a few years ago platinum cost 2,700 roubles per pood of 36 lbs. In 1893, an English firm acquired the decadal production of the Tagil mines at a price of 8,000 roubles per pood. A French electrical company has just completed a contract with the remaining Ural Mines for 10 years' output at the rate of 12,500 roubles per pood; that is, about 10 times the price of gold. The next advance is likely to be largely in excess of even these figures.

We think we may safely say that platinum has never been, and that in our day it will never be, "10 times the price of gold." We may go very much further, and state that, in our opinion, it is unlikely that platinum, which in October, 1890, reached, in London, £4 4s. per ounce troy, will ever again be quite equal in value to gold. Our contemporary, in fact, seems to be unaccountably at fault in its arithmetic. Without aiming at absolute accuracy in this direction, we may take the value of the rouble at 3s. 2d., and that of the *pood*, or *pud*, at 36 lbs. avoirdupois. If platinum a few years ago cost 2,700 roubles per pood, its first cost price at that time per ounce troy was about 16s. 3d. And if a French electrical company has paid 12,500 roubles per pood, this price translated into English is about 4·63 times greater than the above, viz., 75s. 3d. per ounce troy. Now, taking the price of fine gold at 84s. per ounce troy, this maximum prime cost of platinum would be, not "10 times the price of gold," but only about nine-tenths of the price of gold. According to our notes, the prices of platinum in the year 1890—when the metal reached the highest value—were :—In June, 32s. per ounce troy; in October, 84s. per ounce troy; in November, 65s. per ounce troy. Some amongst our readers could, no doubt, supply more ample figures respecting the past, and the probable future fluctuations in price of this metal, which is of such importance in the manufacture of incandescence lamps, and in many other directions in science.

Electricity on Japanese War Vessels.—An Eastern contemporary says that the Japanese Legation in Paris has forwarded to the French Government a report relating to the recent naval combats, in which it is stated, with regard to the electric installations on board the Mikado's warships, that the interruptions of current which took place were not caused, as has been said, by the recoil of the guns, but by the bursting of Chinese shells. The working of the ordnance manœuvred by electricity was not interfered with. The electric wires used for igniting charges were, however, broken by the vibration set up by the firing of the heavy guns.

Errata.—Readers of the article on "Niagara" in our last issue will doubtless have noticed a printer's error which occurred in the last two lines of the first column of page 317. This should have read, "arrive at the conclusion that the less he says the better."

In Captain Benest's letter in our last issue on "Electrical Communication between Lightships and the Shore," for April 5th, 1885, in the first line of the last paragraph but one, read April, *1895*.

The "Telpherage" System.—A *Morning Post* correspondent strongly recommends Prof. Fleeming Jenkin's "telpherage" system as an aid to the construction of the proposed Uganda Railway. "On the completion of the permanent line, the telpherage plant could be utilised for extensions or feeder and telegraph lines. I can see no electrical, mechanical, or other impossibilities."

Telephonic Transmitters.—Carbon is generally stated to be the only known material suitable for the essential part of telephonic transmitters. It is suggested that *lithanode*, or compact peroxide of lead, would answer the same purpose. Whether it would do so as well or better than carbon could be decided only by an experimental comparison.

Three-Phase Transmission Plant.—One of the latest converts to the use of electricity in mills is the Boston Duck Company, of Bondsville, Mass., who, according to a trans-Atlantic exchange, own mills partly operated by water and partly by steam. From the water they are able to derive about 600 H.P. over their present steam plant, consisting of two 250-H.P. engines, one being run condensing and furnishing power alone, the other non-condensing and being used partly for power and partly to furnish exhaust steam to the dye houses. The dye houses, however, require the exhaust steam from about only 100 H.P. Thus if the power were not required in the mill to help out the water wheels, the condensing engine could be shut down entirely and the other engine could be run at about half its capacity only. Three thousand feet below the mills, this company own another water privilege on a difference in level of 22 feet. This was developed some years ago, and the company even went to the expense of building a foundation for a mill before they decided to give up the project. Since that time electricity has come upon the scene, and the heretofore unutilised water power has now become of considerable value. Wheels are to be set up in the unused mill, and 500 H.P. is to be transmitted back to the mills at present in operation at Bondsville. This will enable them to dispense almost entirely with their present steam plant. The General Electric Company have undertaken to instal the necessary electrical apparatus for this plant. It will consist of one three-phase 400-kw. 900-volt generator and one synchronous motor of similar size, which will develop 485 H.P. on its pulley. The loss in the line has been calculated at about 3 per cent. only. In estimating the economy effected by the introduction of electricity, the Boston Duck Company have announced that they will not count the cost of the development of the second water power made in 1880, when calculating the operating expenses of the complete plant, as the money put out for the hydraulic improvements cannot be recovered, and will not therefore be counted in as part of the present development.

Personal.—Mr. Laurence M. Waterhouse, A.M.I.E.E., has been appointed to the post of Lecturer in Electrical Engineering, Telegraphy and Telephony, at the County Polytechnic at Croydon. Mr. Waterhouse previously held a similar appointment at the Brighton Municipal Technical School. He has also been with the Peninsular and Oriental Steam Navigation Company as electrician on their Royal Mail Steamships, and leading hand on their repairs staff at Royal Albert Dock workshops. He holds the full technological certificate, first class in honours electric light, &c., City and Guilds of London Institute, and was medallist in his year, 1890, at the Heriot-Watt College, Edinburgh, in electrical engineering, under Prof. R. M. Walmsley, D.Sc. Our readers will perhaps remember having seen letters of his in the Electrical Review on "Electrical Education" and other subjects. Mr. Waterhouse is now engaged as electric inspector to the lighting of the Royal Lunatic Asylum at Aberdeen, but starts his duties at Croydon on 29th inst. Mr. L. M. Waterhouse is to succeed Mr. C. H. Yeaman as lecturer in electrical engineering and in telegraphy, and to conduct the practical laboratory classes at that Institute. Mr. Yeaman's students were very successful at the May examinations, and Mr. Yeaman himself obtained the silver medal in honours' telegraphy, while his assistant, Mr. Mills, took the silver medal in ordinary grade electric lighting. Mr. Mills has now been appointed assistant lecturer and laboratory demonstrator under Mr. Waterhouse. By a curious change in the programme of the City and Guilds of London Institute, it will be noted that whereas last year students could be examined in both telegraphy and in electric lighting, the next examinations are fixed for the same evening. This precludes the number of successes obtained at this Institute from coming up to the standard reached at the end of last session.

"Great Things Rush Into, or Against Each Other." In the *London Gazette*, under "Adjudications," we observe that an order was, on 9th inst., made in the case of Doctor Joseph Whatmough, trading as D. J. Whatmough and J. and P. Dyer, and formerly as W. Mason, at 39 and 41, High Street, Oldham, Lancs, his business being that of a hosier, tailor and draper, and electrical engineer and fitter.

First Commercial Use of the Niagara Power.—The New York *Electrical Engineer* publishes a special despatch from Niagara Falls of August 26th, which says: "At 7 o'clock this morning the Niagara Falls Power Company first turned on the electric power generated by its dynamos and turbines from the torrent of Niagara River for actual commercial purposes. The current was transmitted to the works of the Pittsburgh Reduction Company, which a few moments later opened for business with a score of men. To-morrow morning 40 men will be at work. The official beginning of the commercial enterprise was witnessed by the chief officials of the Power Company and affiliated concerns with great satisfaction. The current was generated by the second dynamo, and is estimated to have been about 2,000 horse-power.

Resuscitation after Electric Shock.—Our New York namesake says that a lineman in the employ of the Rochester Gas and Electric Company, received a shock from a live wire at Rochester, N.Y., on August 28th, and was apparently dead for six minutes, when he recovered consciousness, after being subjected to the d'Arsonval treatment. His right hand and wrist were badly burned, but he was otherwise uninjured. The wire he came in contact with carried 1,600 volts, and it is reported that he received the full voltage by short-circuiting the line with his body. He had been in the company's employ for 14 years.

The Electro-Harmonic Society.—On the evening of the 28th inst., the first Smoking Concert of the tenth season will take place, the programme of which may be seen in our business columns. Doubtless members have already received notification of the fact that the three concerts previous to Xmas will not be held on Fridays as has hitherto been the case. These changes are due to a combination of circumstances which, to an extent, the executive committee could not control. The resumption of these pleasant evenings will doubtless be welcome to the supporters and friends of the Society.

A New Light Railway.—Lady Newnes, on Tuesday, turned the first sod of a light railway which is about to be constructed, and which will run from Barnstaple, the capital of North Devon, through a rich agricultural district, to the Bristol Channel. The stations will not be visible from either Lynton or Lynmouth, so that it will not greatly interfere with the scenery. The construction of the line is largely due to Sir George Newnes, who has a residence at Lynton; to Mr. Jeune, the brother of the President of the Divorce Court, and other influential gentlemen.

NEW COMPANIES REGISTERED.

Pioneer Syndicate of the Capital and Counties Electricity Supply Company, Limited (45,144).—This company was registered on September 3rd with a capital of £5,000 in £1 shares, with objects as fully set forth in the title. The subscribers are (with one share each):—P. Greville, Osmanthorpe, Laleham, electrician; F. Wright, 31, Pretoria Avenue, Walthamstow, clerk; C. E. Masterman, Northwood, Middlesex, engineer; C. F. Croll, 51, Barrington Road, S.W., clerk; E. Mann, 9, Palace Chambers, Westminster, clerk; J. L. Higgs, 43, Finsbury Square, E.C., solicitor; S. Sellon, C.E., 5, Victoria Street, S.W. Registered without articles of association by J. L. Higgs, 43, Finsbury Square, E.C.

Westralian Electric Lighting and Supply Company, Limited (45,136).—This company was registered on September 3rd, with a capital of £80,000, in £1 shares, to enter into an agreement with Westralia Limited, and to carry on in Western Australia and elsewhere the business of electricians, electrical and mechanical engineers, suppliers of electricity, electric light contractors, &c. The subscribers (with one share each) are:—A. Marks, 115B, City Road, E.C., clerk; G. Mellors, 77, Cambridge Street, S.W., chartered accountant; R. A. Webster, 52, New Broad Street, E.C., accountant; L. Bulger, 2, Amoe Road, Hammersmith, stenographer; B. O. C. Orlebar, Palace Chambers, Westminster, accountant; F. A. Thompson, 54, Old Broad Street, E.C., engineer; J. G. Macintosh, 65, Cheverton Road, Walthamstow, clerk. The number of directors is not to be less than three, nor more than five; the subscribers are to appoint the first. Qualification, £200; remuneration, £150 each per annum, and £50 extra for the chairman. Registered by Sutton and Co., 3, Great Winchester Street, E.C.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Greenwood & Batley, Limited (27,098).—This company's annual return was filed on July 22nd. The capital is £400,000 in £10 shares (14,000 preference); 11,066 preferred and 18,052 ordinary have been taken up, and 2,066 preference and 4,666 ordinary have been issued as paid. £10 each share has been called on 6,934 preference and 12,134 ordinary, and £3 per share on the rest, and £198,834 has been paid.

Hargreaves & Shaw, Limited (43,132).—This company's statutory return was filed on June 24th. Forty-three shares have been taken up out of a capital of £5,000 in £5 shares, and have been paid for in full.

Hooper's Telegraph and India-Rubber Works, Limited (40,947).—This company's statutory return was filed on July 3rd. The capital is £50,000 in £10 shares (1,000 preference), 1,000 ordinary and 1,000 preference taken up, and the preference issued as fully paid. £10 per share has been called on 498 ordinary, £2 on 250, and 2s. on 252, and £5,505 4s. has been paid.

International Electric Storage, Limited (40,850).—This company's statutory return was filed on July 31st, when seven shares were taken up out of a capital of £200,000 in £5 shares (4,000 preference). The annual return was filed on August 1st, and 9,500 ordinary and 600 preference were then taken up, 9,200 ordinary were issued as paid, and the full amount has been called and paid on the rest.

British Electro-Chemical Agency, Limited (34,592).—This company's annual return was filed on August 23rd. The capital is £50,000 in 5,000 ordinary shares of £5 each and 2,500 vendors' shares of £10 each, of which the latter have been issued as paid. 2,500 of the ordinary have been taken up, and £4 per share has been called. £9,529 has been paid, leaving £471 unpaid.

Bournemouth and District Electric Supply Company, Limited (34,129).—This company's annual return was filed on August 14th. 5,725 shares have been taken up out of a capital of £50,000 in £5 shares, and the full amount has been called and paid.

British Thomson-Houston, Limited (28,486).—This company's annual return was filed on July 29th. 7,649 shares have been taken up out of a capital of £100,000 in £10 shares, and 4,175 have been considered as paid. Calls of £10 per share have been made on 3,081, £7 10s. on 237, £2 10s. on 50, and £5 on 106, and £33,242 has been paid, leaving 125 unpaid.

Edison and Swan United Electric Light Company, Limited (18,984).—This company's annual return was filed on August 15th. The capital is 1,000,000 in £5 shares (150,000 "A" and 50,000 "B"). 106,400 "A" and 23,564 "B" have been taken up, and 17,139 "A" and 23,564 "B" have been issued as fully paid, while 89,261 "A" have been issued with £2 10s. treated as paid; 10s. per share has been called on these last, and £44,630 10s. has been paid.

Val d'Aosta Electric Power Company, Limited (44,205).—The registered address of this company, now situate at 32, Victoria Street, S.W., was filed on July 5th.

Alternate Current Electro-Motor Syndicate, Limited (43,836).—The statutory return of this company was filed on August 21st. 5,037 shares have been taken up out of a capital of £6,000 in £1 shares, and 2,000 are considered as paid. 6s. per share has been called on the others, and £911 2s. has been paid.

W. and J. Robinson & Co., Limited (43,339).—The registered office of this concern is now situate at 103, Balliol Road, Bootle, Lancs.

Western Counties Electric Light and Power Syndicate, Limited (36,294).—This company's annual return was filed on August 23rd. The capital is £25,000, in £50 shares (380 ordinary and 120 deferred), and 85 ordinary and 120 deferred have been taken up, the latter being considered as paid. The full amount has been called and paid on the ordinary shares.

United River Plate Telephone Company, Limited (23,654).—This company's return was filed on July 31st. 58,000 shares have been taken up out of a capital of £500,000, in £5 shares, and 16,000 have been considered as paid. The full amount has been called and paid on 42,000 shares.

African Direct Telegraph Company, Limited (21,895).—This company's annual return was filed on August 8th. 23,600 shares have been taken up out of a capital of £300,000 in £10 shares, and the full amount has been called and paid.

Richmond (Surrey) Electric Light and Power Company, Limited (36,782).—This company's annual return for 1894 was filed on August 31st; 4,066 shares have been taken out of a capital of £50,000, in £5 shares, and the full amount has been called and paid.

Dixon & Corbitt and R. S. Newall and Company, Limited (24,228).—This company's annual return was filed on August 27th. The capital is £120,000, in £10 shares (of which 6,000 are preference); 6,000 ordinary and 1,957 preference have been taken up, and all the ordinary and 250 preference have been issued as fully-paid; £8 per share has been called on 1,707 preference, and £13,648 has been paid, leaving £8 unpaid.

CITY NOTES.

The Brush Electrical Engineering Company, Limited.

The sixth annual report for the year ended June 30th, 1895, to be presented to the general meeting at Cannon Street Hotel, E.C., on Monday next, 23rd inst., at 12 o'clock noon, states that the profit and loss account shows a gross profit of £37,858 4s. 5d, after providing for bad and doubtful debts to the amount of £2,205 17s. 9d., and writing down the value of shares and debentures in other companies, as shown in the balance-sheet. After deducting from the gross profit, general charges, maintenance of buildings, plant and patents, staff bonuses under the company's profit-sharing scheme, and interest on debenture stock, there remains a net balance of profit, after including the amount brought forward from last year, of £11,329 12s. 8d. An interim dividend at the rate of 6 per cent. upon the preference shares, and at the rate of 5 per cent. upon the ordinary shares, has been already paid for the half-year ended December 31st, 1894, amounting to £12,150. It will be seen that the net profit for the year, exclusive of the amount brought forward, is £7,541 3s. 8d. The preference shareholders have already received £5,400 of this amount by way of interim dividend as above, and they will be entitled to receive the balance of £2,141 3s. 8d. before the ordinary shareholders receive further dividends. Whilst the directors regret this result of the year's operations, which shows a decrease of net profit as compared with last year of £19,739 8s. 5d., they think it right to state that it is solely due to loss incurred during the second half of the company's financial year in connection with the contract which the company is carrying out for the City of London Electric Lighting Company, Limited; and arises out of differences between the two companies as to the obligations involved under the contract. The directors are glad to be able to state that these differences are now at an end, and work under the contract is being again proceeded with. During the year the sum of £2,646 1s. 9d. has been expended on capital account, upon extensions of buildings and plant at the Loughborough works, and new patents taken over by the company. The Austrian business of the company, carried on from the Vienna factory of Messrs. Kremenezky Mayer & Co., has yielded improving results during the past year, and is now established upon a thoroughly profitable basis. The Australasian branch, having its headquarters at Sydney, New South Wales, has also shown a satisfactory profit for the year ended April 30th last, and with the improved commercial prospects in the colonies, correspondingly favourable results from this branch of the company's business may fairly be expected. The contract and installation department has been fully employed during the 12 months under review, and central electricity supply stations for the municipalities of Leicester and Worcester, and for the Dover Electricity Supply Company, have been equipped with the company's electrical plant, and opened during the year. The Loughborough works are at present fully engaged on orders, and sufficient work is in hand and in prospect to maintain them so for some time to come. In the electrical shops plant is in course of manufacture for the equipment of electricity supply stations in St. Luke's, Middlesex, the Wandsworth district, and for the lighting of Valetta and the Government works at Malta, for which an order has recently been received. The rolling stock and car departments are engaged upon the construction of locomotives for the Beira railway, of cars for the Rouen Electric Tramways Company, and other orders. The directors are pleased to report that they have made arrangements for the manufacture of a new high speed enclosed engine of a novel and simple construction, the invention of the company's joint manager and chief engineer, Mr. J. S. Raworth. There is at the present time a large demand for engines of this class. The new engine has been submitted to Prof. W. Cawthorne Unwin, F.R.S., and to Mr. W. H. Maw, M.I.M.E., copies of whose reports are given with the report. The bonus profit-sharing scheme introduced among the company's staff and workmen two years ago is giving general satisfaction among the *employés*, and the directors are satisfied that the scheme is working well. In order to provide capital to meet the large expansion of the company's business which has taken place since the last issue of capital early in 1893, the directors have decided to make an issue of second 4½ per cent. debenture stock to the amount of £105,000, which will be allotted at par to the holders of preference and ordinary shares. The entire interest charge on the company's debenture stock, including the £105,000 now to be issued, will then stand at £10,350 per annum. The average annual net profit (including debenture interest) for the past six years, since the company was formed in 1889, amounts to £25,337. The stock will, therefore, be amply secured. The increase in the extent and volume of the company's business, especially during the past few years, is largely due to the development in this country of municipal and private electricity supply from central stations, of which business the company has been successful in securing a substantial share. The manufacture of steam engines for electrical engineering purposes has also been undertaken during that period, and upwards of 35,000 horse-power have been sold. The company are also giving close attention to electric traction and electric elevator work, in both of which directions an important development appears to be imminent. Mr. Edward Woods and Mr. A. Ayres are the directors who retire by rotation, and, being eligible, offer themselves for re-election. The auditors, Messrs. Cooper Bros. and Co. also retire, and offer themselves for re-election.

Rockhampton Gas and Coke Company, Limited.

From the directors' report for the half-year ended June 30th, 1895, we extract the following particulars regarding the electric lighting department:—

The electrical operations show a profit of £303 13s. 9d., from which has been paid £300 interest upon the whole of the company's debentures, leaving an unappropriated balance of £3 13s. 9d. to the credit of the profit and loss account of this section of the company's business. . . . . During the half-year some additions, improvements, &c., have been made to the E. L. plant and buildings. Reference was made in the last report to the engagement in London of a new electrical engineer. The candidate selected from a very large number of applicants by the company's agents, after careful scrutiny into his antecedents and past professional experience, was Mr. E. F. J. Hewlett, M.I E.E., who has been connected for some years with large electrical firms in England.

Assets.

	£	s.	d.
By Sundry debtors for gas and electric light	1,573	2	9
„ Electric light plant	9,565	16	10
„ Electric light fittings on rental	1,036	12	11
„ Electric light fittings in stock	1,024	18	1

Profit and Loss Account for the half-year ended June 30th, 1895.

Electric Light Operations.

Dr.

	£	s.	d.
To Generating electric current	627	2	3
„ Advertising	7	6	7
„ Management, &c.	62	8	6
„ Printing	4	10	0
„ Interest	300	0	0
„ Public lamps	2	19	7
„ Stationery	12	16	10
„ Insurance	23	15	1
„ L. expenses	12	1	4
„ Balance	3	13	9
	£1,056	13	11

Cr.

	£	s.	d.
By Electric current sales	838	15	9
„ Sundries	44	3	6
„ Electric light fitting account	141	16	9
„ Interest	31	17	11
	£1,056	13	11

There is also carried to reserve for maintenance and improvement of electric lighting plant, £221 4s. 1d.

Smoke and Fumes Annihilator Company, Limited.

A general meeting of the shareholders of the Smoke and Fumes Annihilator Company, Limited, was held on Tuesday at Cannon Street, Hotel, E.C., to present the final accounts of the liquidator.

Mr. J. Satchell Hopkins presided, and stated that the whole of the money paid in by the allottees had been returned, with the exception of 4s. per share. Out of that 4s. per share, after paying all expenses, a balance of £9 8s. 3d. remained in hand, which he had paid over to Mr. Arnold, the secretary, for the trouble he had been put to from the date of the liquidation to the present time. The chairman then moved the adoption of the accounts, which was seconded and carried.

A resolution was subsequently passed, authorising the liquidator to keep the books and accounts until the time required by the Act.

The Direct Spanish Telegraph Company, Limited.—The board has decided to pay, in addition to the dividend at the rate of 10 per cent. per annum on the preference shares, an interim dividend at the rate of 4 per cent., free of income-tax, on the ordinary shares, both for the half-year ended June 30th, 1895.

Royal Electric Company of Montreal.—The Bank of Montreal will pay, on and after 1st prox., the coupons then due of the 4½ per cent. debenture loan for £120,000.

Scottish House-to-House Electricity Company, Limited.—The transfer books will be closed from September 19th to 30th, both days inclusive.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending September 15th, 1895, amounted to £808; week ending September 16th, 1894, £836; decrease, £18; total receipts for half-year, 1895, £9,316; corresponding period, 1894, £9,402; decrease, £86.

The Liverpool Overhead Railway Company. The receipts of this railway for the week ending September 15th, 1895, amounted to £1,278; corresponding week last year, £1,084; increase, £194.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending September 13th, 1895, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £2,725.

SHARE LIST OF ELECTRICAL COMPANIES.

TELEGRAPH AND TELEPHONE COMPANIES.

Present issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1892.	1893.	1894.	Closing Quotation, Sep. 11th.	Closing Quotation Sept. 18th.	Business done during week ended Sept. 18th, 1895. Highest.	Lowest.
173,400£	African Direct Teleg., Ltd., 4 % Deb.	100	...	4 %	4 %	102 —105	102 —105	...	...
1,912,880£	Anglo-American Teleg., Ltd.	Stock	£2 15s.	£2 11s.	£2 2s.	48 — 50	48 — 50	49	...
2,993,560£	Do. do. 6 % Pref.	Stock	£5 10s.	£5 2s.	£4 4s.	89 — 90	89 — 90	89⅝	89
2,993,560£	Do. do. Defd.	Stock	...	...	...	8½— 9	8½— 9	8⅝	8⅝
130,000	Brazilian Submarine Teleg., Ltd.	10	6¼% §	6¼% §	...	13¾— 14¼	13¾— 14¼	14¼	13 1/16
75,000£	Do. do. 5 %, Debs., 2nd series, 1906	100	5 %	5 %	...	111 —115	111 —115	...	...
44,000	Chili Telep., Ltd., Nos. 1 to 44,000	5	10%‖ §	... §	2½%	3 — 3½	3½— 4	3 1/16	...
10,000,000$	Commercial Cable Co.	$100	7 %	7 %	7 %	160 —165	160 —165	...	...
224,850	Consolidated Telep. Const. and Main., Ltd.	10/-	2 % §	2 % §	1½%	1/16— 3/16	1/16— 3/16	...	...
16,000	Cuba Teleg., Ltd.	10	8 %	8 %	8 %	13 — 14	13 — 14	...	...
6,000	Do. 10 % Pref.	10	10 %	10 %	10 %	20 — 21	20 — 21	...	...
12,931	Direct Spanish Teleg., Ltd.	5	4 %	4 %	4 %	4 — 5	4 — 5	...	...
6,000	Do. do. 10 % Cum. Pref.	5	10 %	10 %	10 %	9½— 10¼	9½— 10¼	...	...
30,000£	Do. do. 4½ % Debs. Nos. 1 to 6,000 ...	50	...	...	4½%	103 —106 %	103 —106 %	...	...
60,710	Direct United States Cable, Ltd.	20	3½% §	2⅝% §	2 %	9 — 9⅛	9 — 9⅛	...	...
400,000	Eastern Teleg., Ltd., Nos. 1 to 400,000	10	6½% §	6½% §	6½%	17⅛— 17⅜	17⅛— 17⅜	17⅜	17
70,000	Do. 6 % Cum. Pref.	10	6 % §	6 % §	6 %	18 — 18½	18 — 18½	18	...
102,100£	Do. 5 % Debs., repay. August, 1899	100	5 %	5 %	5 %	106 —109	106 —109	...	...
1,297,837£	Do. 4 % Mort. Deb. Stock Red.	Stock	4 %	4 %	4 %	129 —132	129 —132	130⅜	...
250,000	Eastern Extension, Australasia and China Teleg., Ltd. ...	10	7 %	7 %	7 %	17¾— 18	17⅞— 18⅛	18 3/16	17 15/16
54,100£	Do. 5 % (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	5 %	5 %	5 %	102 —106	102 —106	...	...
194,300£	Do. do. Bearer, 1,050—3,975 and 4,327—6,400	100	5 %	5 %	5 %	103 —106	103 —106	...	...
320,000£	Do. 4 % Deb. Stock	Stock	4 %	4 %	4 %	127 —130	128 —131	...	...
80,600£	Eastern and South African Teleg., Ltd., 5 % Mort. Deb. 1900 redeem. ann. drgs., Reg. Nos. 1 to 2,343	100	5 %	5 %	5 %	102 —106	102 —106	...	...
107,600£	Do. do. do. to bearer, 2,344 to 5,500	100	5 %	5 %	5 %	103 —106	103 —106	...	...
300,000£	Do. 4 % Mort. Debs. Nos. 1 to 3,000, red. 1909	100	4 %	4 %	4 %	106 —109	107 —110	...	...
200,000£	Do. 4 % Reg. Mt. Debs. (Mauritius Sub.) 1 to 8,000	25	4 %	4 %	4 %	113 —116	113 —116%	...	...
180,227	Globe Telegraph and Trust, Ltd.	10	4⅞% §	4⅝% §	4⅛%	10¼— 10⅜	10¼— 10⅜	10 7/16	10¼
180,042	Do. do. 6 % Pref.	10	6 % §	6 % §	6 %	16⅞— 17⅛	17 — 17⅛	17 1/16	17
150,000	Great Northern Teleg. Company of Copenhagen	10	8⅜% §	8⅜%	8⅜%	21¾— 22¼	21¾— 22¼	22⅛	...
180,000£	Do. do. do. 5 % Debs.	100	5 %	5 %	5 %	103 —106	103 —106	104½	...
17,000	Indo-European Teleg., Ltd.	25	10 %	10 %	10 %	50 — 53	50 — 53	50½	...
100,000£	London Platino-Brazilian Teleg., Ltd. 6 % Debs.	100	6 %	6 %	6 %	104 —108	104 —108	...	...
484,597	National Teleph., Ltd., 1 to 484,597	5	5 % §	5 % §	5 %	6⅛— 6⅜	6⅛— 6⅜	6 5/16	6 5/16
15,000	Do. 6 % Cum. 1st Pref.	10	6 %	6 %	6¼%	16 — 18	16 — 18	16½	...
15,000	Do. 6 % Cum. 2nd Pref.	10	6 %	6 %	6 %	15 — 16	15 — 16	15⅞	15½
119,234	Do. 5 % Non-cum. 3rd Pref., 1 to 119,234	5	5 %	5 %	5 %	6⅛— 6⅜	6⅛— 6⅜	6⅜	6⅛
1,100,000£	Do. 3½ % Deb. Stock Red.	Stock	3½%	3½%	3½%	106 —108	106 —108	106¼	106
171,504	Oriental Teleph. & Elec., Ltd., Nos. 1 to 171,504, fully paid	1	...	...	4½%	1/16— 1/16	1/16— 1/16	...	...
100,000£	Pacific and European Tel., Ltd., 4 % Guar. Debs, 1 to 1,000	100	4 %	4 %	4 %	108 —111	108 —111	...	...
11,839	Reuter's Ltd.	8	5 %	0 %	*nil*	3½— 4½	4 — 5	4¼	...
3,381	Submarine Cables Trust	Cert.	...	...	...	127 —132	127 —132	130½	...
58,000	United River Plate Teleph., Ltd.	5	...	...	...	2¾— 3½	2¾— 3½	...	...
146,733£	Do. do. 5 % Debs.	Stock	5 %	5 %	5 %	92 — 97	93 — 98	...	...
15,609	West African Teleg., Ltd., 7,501 to 23,109	10	..	...	*nil*	5½— 6½	5½— 6½	...	...
238,300£	Do. do. do. 5 % Debs.	100	5 %	5 %	5 %	104 —107	104 —107	106⅜	...
30,000	West Coast of America Teleg., Ltd.	10	...	...	...	1 — 2	1 — 2	...	...
150,000£	Do. do. do. 8 % Debs., repay. 1902	100	8 %	8 %	...	99 —104	99 —104	...	...
64,248	Western and Brazilian Teleg., Ltd.	15	2½%	2½%	3 %	10 — 10½	10 — 10½	10 5/16	10⅛
33,129	Do. do. do. 5 % Pref. Ord. ...	7½	5 %	5 %	5 %	6½— 7	6¾— 7	...	...
33,129	Do. do. do. Def. Ord.	7½	...	...	1 %	4 — 4½	4 — 4½	4 5/16	...
165,200£	Do. do. do. 6 % Debs. "A," 1880 Red.	100	6 %	6 %	6 %	102 —106	102 —106	...	...
206,400£	Do. do. do do "B," do.	100	6 %	6 %	6 %	102 —106	102 —106	...	...
88,321	West India and Panama Teleg., Ltd.	10	⅛%	1/16%	⅛%	¾— 1	¾— 1	¾	...
34,563	Do. do. do. 6 % Cum. 1st Pref.	10	6 %	6 %	6 %	10½— 10⅝	10½— 10⅝	10⅝	...
4,669	Do. do. do. 6 % Cum. 2nd Pref.	10	6 %	6 %	6 %	8½— 9½	8½— 9½	...	...
80,000£	Do. do. 5 % Debs. No. 1 to 1,800 ...	100	5 %	5 %	5 %	110 —113	110 —113	...	...
1,777,000$	Western Union of U. S. Teleg., 7 % 1st Mort. Bonds ...	$1000	7 %	7 %	7 %	113 —118	113 —118	...	...
164,300£	Do. do. 6 % Ster. Bonds.	100	6 %	6 %	6 %	100 —103	100 —103	...	...

ELECTRICITY SUPPLY COMPANIES.

30,000	Charing Cross and Strand Electy. Supply	5	5 %	4½%	4½%	5½— 5⅝	5½— 5⅝	...	...
10,277	*Chelsea Electricity Supply, Ltd., Ord., Nos. 1 to 10,277 ...	5	...	...	...	6⅝— 7¼	7 — 7⅛	...	...
60,000	Do. do. do. 4½ % Deb. Stock Red. ...	Stock	...	...	...	116—119	116 — 119	...	...
40,000	City of London Elec. Lightg. Co., Ltd., Ord. 40,001—80,000	10	...	...	5 %	15 — 15½	14 — 15	15¼	15 1/16
40,000	Do. do. 6 % Cum. Pref., 1 to 40,000	10	6 %	6 %	6 %	15½— 16½	15 — 16	16	15 15/16
300,000	Do. 5 % Deb. Stock, Scrip. (iss. at £115) all paid	...	5 %	5 %	5 %	133 —137	133 —137	135½	134⅝
22,475	County of London and Brush Prov. Elec. Ligtg., Ltd., Ord. 1—22,475	10	...	...	...	8½— 9½	8½— 9½	...	...
10,000	Do. do. do. 6% Pref., £4 pd., 40,001—50,000	10	...	...	...	6⅞— 7¼	6⅞— 7¼	...	...
50,000	†Liverpool Electric Supply, all paid	5	5 %	5 %	5¼%	7⅞— 8⅛	7⅞— 8⅛	...	...
49,900	*Metropolitan Electric Supply, Ltd., 101 to 50,000 ...	10	2 %	2½%	3 %	12½ — 13	12½— 12⅝	12½	12½
150,000£	Do. 4½% first mortgage debenture stock	...	4½%	4½%	...	117 —119	117 —119	...	...
6,452	Notting Hill Electric Lightg. Co., Ltd.	10	...	...	1 %	8½— 9	8½— 9½	9½	9⅛
19,980	St. James's & Pall Mall Elec. Light Co., Ltd., Ord., 101-20,080	5	7½%	4½%	6½%	8¼— 8⅜	8¼— 8⅜	...	...
20,000	Do. do. 7 % Pref., 20,081 to 40,080	5	7 %	7 %	7 %	9 — 10	9 — 10	...	...
67,900	*Westminster Electric Supply Corp., Ord., 101 to 60,000 ...	5	3½%	4 %	5 %	8⅞— 9¼	8⅞— 9¼	9	8⅞

* Subject to Founder's Shares. † Quotations on Liverpool Stock Exchange.

Unless otherwise stated all shares are fully paid. ‡ Dividends paid in deferred share warrants, profits being used as capital

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

SHARE LIST OF ELECTRICAL COMPANIES—*Continued.*

ELECTRICAL RAILWAY, MANUFACTURING, AND INDUSTRIAL, COMPANIES.

Present Issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1892.	1893.	1894.	Closing Quotation, Sept. 11th.	Closing Quotation, Sept. 18th.	Business done during week ended Sept. 18th, 1895. Highest.	Lowest.
90,000	Brush Elecl. Enging. Co., Ord., 1 to 90,000...	3	6 % §	6 % §	...	1⅝— 1⅞	1½— 1⅝	1⅝	1⅜
90,000	Do. do. Non-cum. 6 % Pref., 1 to 90,000	2	6 % §	6 % §	...	1⅞— 2⅛	1⅞— 2	2⅛	1¾
125,000*l*	Do. do. 4½ % Perp. Deb. Stock.... ...	Stock	4½%	4½%	...	111 —114	111 —114	112	...
630,000*l*	City and South London Railway	Stock	8%	8%	1½%	38 — 40	38 — 40	...	...
28,180	Crompton & Co., Ltd., 7 % Cum. Pref. Shares, 1 to 28,180	5	7 % §	7 % §	...	1 — 2	1 — 2	...	...
89,261	Edison & Swan United Elec. Lgt., Ltd., "A" shrs, £3 pd. 1 to 89,261	5	...	...	5 %	2 — 2¼xd	2 — 2¼xd	..	...
100,000	Do. do. do. 4½% Deb. Stock Red....	Stock	..	...	4½%	104 —107	104 —107	...	...
110,000	Electric Construction, Ltd., 1 to 110,000	2	*nil*	*nil*	*nil*	⅛— ¾	⅛— ¾	...	...
12,845	Do. do. 7 % Cum. Pref., 1 to 12,845 ...	2	7 %	7 %	7 %	2¼— 2⅝	2¼— 2⅝	2 5/16	2¼
91,195	Elmore's Patent Cop. Deposg., Ltd., 1 to 70,000	2	*nil*	*nil*	...	⅛— 1	⅛ — 1	...	...
69,385	Elmore's Wire Mfg., Ltd., 1 to 69,385, issued at 1 pm. ...	2	*nil*	*nil*	...	⅝— 1⅛	⅝ — 1⅛	⅝	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300	5	*nil* §	*nil* §	...	¼— ¾	¼— ¾	...	...
9,600*l*	Greenwood & Batley, Ltd., 7 % Cum. Pref., 1 to 9,600 ...	10	7 %	*nil*	...	6½— 7½	6½— 7½	...	...
10,000	Henley's (W. T.) Telegraph Works, Ltd., Ord.	10	5 %	5 %	6 %	11¾— 12¼	12¼— 12⅝	12 1/16	12¼
3,000	Do. do. do. 7% Pref.	10	...	...	...	15 — 16	15 — 16	...	...
50,000	Do. do. do. 4½ Mort. Deb. Stock	Stock		...	...	104 —107	104 —107	...	...
50,000	India-Rubber, Gutta Percha and Teleg. Works, Ltd. ...	10	12½%	12½%	10 %	19 — 21	19 — 21	20⅛	19⅞
200,000*l*	Do. do. do. 4½ % Deb., 1896	100	4½%	4½%	4½%	102 —104	102 —104	...	...
37,500	†Liverpool Overhead Railway, Ord.	10	...	1 %	1½%	11½— 11⅝	12 7/8—13⅛	12¾	12½
10,000	† Do. do. Pref., £10 paid	10	...	5 %	5 %	15 — 15½	15 — 15½		
37,350	Telegraph Constn. and Maintce., Ltd.	12	15 %	20 %	20 %	43 — 45	43 — 45	44¼	43¾
150,000	Do. do. do. 5 % Bonds, red. 1899	100	5 %	5 %	5 %	104 —107	104 —107	...	...
54,000*l*	Waterloo and City Railway, Nos. 1 to 54,000, £4 paid ...	10	...	...	...	4½— 4¾	4½— 4¾	4¾	4 15/16

† Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid. ¶ Last dividend paid was 50% for 1890.
Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.
Crompton & Co.—The dividends paid on the ordinary shares (which have not a Stock Exchange quotation), are as follows: 1892—0%; 1891—7%; 1890—8%.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Birmingham Electric Supply Company, Ordinary of £5 (fully paid), 5⅞—6¼.
Electric Construction Corporation, 6 % Debentures, 95—100.
House-to-House Company (£5 paid), 4—4½.
Do. do. 7 % Preference, of £5, 8—8½.
Do. do. 4½% Debentures of £100, 108—110.
Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid) 8—8½; 1st Preference Cumulative 6 %, £5 (fully paid), 7—7½.
Liverpool Electric Supply, £5 (fully paid), 7⅞—8¼.
London Electric Supply Corporation, £5 Ordinary, ⅜—½.
Yorkshire House-to-House Electricity Company, £5 Ordinary Shares fully paid, 6⅞—7.

Bank rate of discount, 2 per cent. (February 22nd, 1894).

THE SENSIBILITY OF GALVANOMETERS.

Prof. Stine, in a recent issue of the *Electrical World*, calls attention to the uncertainty and confusion which at present exists relative to the rating of the sensibility of various types of galvanometers. The professor considers this to be the result of a want of thoroughness in dealing with the question, and he makes some attempt to arrive at a rational conclusion as to the proper way of rating the instruments. It is not by any means an easy matter to decide upon a standard method of determining the value of any particular galvanometer, as there are so many points involved. The particular use for which a galvanometer is required is a point upon which sufficient stress is seldom laid, and upon this point Prof. Stine himself does not seem to concentrate sufficient attention, whilst of others too much is made. He complains of the incomplete way in which the subject of galvanometers is dealt with. With this we quite agree, but probably not from the usual standpoints. We know, for example, of Lord Kelvin's investigations relative to the best shape for a galvanometer coil, and some attempt is made by manufacturers to follow this out; but who has attempted to prove, either by mathematical analysis, or by practical experiment, whether there is any real practical value in following out the Kelvin law?

An analysis to be complete, or indeed to be of real value, requires not only to prove a law, but also to determine what results follow from departing from that law. With reference to this, we would cite, as an example, the well-known statement that to produce a maximum effect, the resistance of the coil of a galvanometer should be equal to the external resistance. The correctness of this does not admit of dispute, and it is a generally known law. But how many people are aware that this law may be very largely departed from without materially affecting the result which is obtained by its rigid application? We may, in fact,* to take a very extreme case, make the actual resistance *nine* times as great or as small as the theoretical one, and yet the effect is only to reduce the sensitiveness of the arrangement in the ratio of not 9 to 1, but 9 to 5·5.

What again is the result of making a galvanometer coil of a square instead of the slightly rounded form (before referred to) which theory indicates? It is almost insignificant. It is quite true that "every little helps," and that the rigid carrying out of all the theoretical laws tends towards improving matters, but we contend at the same time that the absence of a *complete* analysis of these theoretical laws gives a false impression, and results in much unnecessary trouble and expense in the design of galvanometers.

Prof. Stine says: "Stress should be laid on the fact that the sensibility of a galvanometer is not correctly stated unless the particular strength of the earth's field in which it was determined is mentioned." This, of course, is perfectly true, but to what extent does this strength vary? Prof. Stine says he has noted working variations of "H" between ·18 and 1·45 C.G.S. There is surely some mistake here; no such large variation actually takes place. One very important point appears to have been entirely overlooked by Prof. Stine, and that is the "resistance" of the galvanometer; this is an important factor in the sensibility of the instrument, as with a given current a low resistance instrument should not give as high a deflection as one of high resistance; the deflection corresponding to a given current ought, in fact, to be reduced to a standard resistance. The sensibility for a given size of coil varies as the square root of the resistance, so that two galvanometers—one of, say, 10 ohms resistance, and the other of 1,000 ohms—should for a

* Kempe's "Handbook of Electrical Testing," 5th Edition, p. 481.

definite current give deflections in the ratio of 1 to 10, not in virtue of one being superior in make to the other, but simply in virtue of difference of resistance. In fact, the sensibility of the instrument should be judged by an expression of the form $\frac{c\,d}{\sqrt{R}}K$, where c is the current, d the deflection, R the resistance of the instrument, and K either a constant, or a quantity dependent upon other factors. The significance of "d" also is an important matter, as two instruments, one with the scale at twice or thrice the distance of the other, might show twice or thrice the number of scale divisions of deflection for a given current, and yet be no more sensitive. A definite distance, of course, as Prof. Stine points out, should be adopted. In any case, the sensibility of an instrument ought to be judged without the control magnet.

We have not ventured to put forward a definite basis upon which the subject may be founded, but that there is some necessity for the same we must admit, and it is one which might with advantage be discussed.

THE CHOICE OF TRANSFORMERS.

By GEORGE ADAMS.

THE paper read before the American North-Western Electric Association by Prof. D. C. Jackson (an extract of which appeared in the New York *Electrical Engineer* of August 28th) contains some points of interest to English electrical engineers. Prof. Jackson comes to the conclusion that considerable economy may be obtained by employing transformers having small iron losses, especially when the transformers are working continuously for long periods.

The tables which Prof. Jackson gives in his paper show remarkably small iron losses as compared with English practice. Looking further into the matter, we find that the difference is due, in the first instance, to the low primary voltage, namely, 1,000 volts customary in American practice, and, secondly, to the somewhat high frequency employed, namely, 125 cycles per second.

Table I., taken from Prof. Jackson's paper, is prepared from tests carried out by Mr. A. H. Ford in the laboratory of the University of Wisconsin on transformers, which are said to represent the latest and best designs by American makers.

Using the formula connecting induction, primary volts, and frequency, namely,

$$B\,A = \frac{e_1\,10^8}{4{\cdot}45\,t_1\,n}, \qquad (1)$$

where
- B = induction,
- A = sectional area of iron core,
- e_1 = primary volts,
- t_1 = number of primary turns,
- n = frequency.

And assuming the cross-sectional area of core, A, and primary turns, t_1, to be constant:

$$B = \frac{10^8}{4{\cdot}45\,A\,t_1} \cdot \frac{e_1}{n}$$

$$\therefore B \propto a \cdot \frac{e_1}{n},$$

or induction varies directly as the primary voltage, and inversely as the frequency; so that a reduction in the primary volts, or an increase in frequency, will result in a diminished induction, and consequent reduction in the iron loss.

Thus, in the case of the English transformer, if the transforming ratio were from 1,000 volts to 100, instead of 2,000 volts to 100, the iron loss would be reduced to 32 watts—everything else being the same—a result which would compare favourably with American practice under the same conditions. Owing to the lower inductions at which the American transformers work, the current on open secondary circuit is also less than is usual in English practice.

The average open circuit current taken over four 1,500-watt American transformers, at frequency 125, is ·069 ampère, while the open circuit current for the aforesaid English transformer works out to ·098 ampère, the difference being due to the higher induction in the iron of the English transformer. This will be clear on inspecting the formulæ (4) (5) and (6):

$$C_o = \sqrt{C_h^2 + C_\mu^2} \qquad (4)$$

$$C_\mu = {\cdot}565\ \frac{B}{\mu} \cdot \frac{l}{t_1} \qquad (5)$$

$$C_h = \frac{\text{Iron loss in watts}}{\text{Primary volts}} \qquad (6)$$

where
- C_o = open circuit current,
- C_h = power current,
- C_μ = magnetising current,
- l = length of magnetic circuit.

TABLE I.

No.	Watts capacity.	Open circuit current.	Watts iron loss.				Watts copper loss. Full load.	Total drop.	Efficiencies. Full load.		All day efficiency.	
		F = 125.	F = 60.	F = 125.	F = 60.			F = 125.	F = 60.	F = 125.	F = 60.	
								Per cent.	Per cent.	Per cent.	Per cent.	
1	1,250	·043	·066	37	48	30	2·5	95	94	85	83	
2	1,500	·076	·124	50	71	45	3·5	95	94	85	81	
3	1,500	·052	·100	32	46	38	4·0	96	95	89	85	
4	2,500	·230	·540	135	230	44	2·5	92	89	77	68	
5	1,800	·075	·600	52	109	67	5·0	94	92	85	75	
6	2,000	·055	·091	42	56	55	5·0	95	94	89	86	
7	1,000	·028	·064	24	28	33	3·0	95	94	87	86	
8	1,500	·073	·113	57	76	31	2·5	94	93	83	79	
9	1,500	·077	·144	43	55	28	3·0	95	95	86	84	

The average iron loss taken over four 1,500 watt American transformers at 1,000 volts in primary, and frequency 125, is 45 watts, and at frequency 60, the average iron loss would be 62 watts.

The iron loss in a 1,500-watt transformer made by a prominent English firm is 79 watts. The primary voltage being 2,000 and the secondary voltage 100; the frequency being the same as in the former case, namely, 125 cycles per second. To account for these differences, we may refer to the diagram, fig. 5, in an article by the writer in the ELECTRICAL REVIEW of August 2nd, on "Transformer Design."

The curve shows the relation between the iron loss in watts and induction, and illustrates the fact that the iron loss in watts varies as a power of the induction.

Referring to formula (5), it will be seen that the magnetising current, and consequently the open circuit current, increases with an increased induction, or with an increase of the ratio $\frac{B}{\mu}$.

Prof. Jackson points out that the iron losses in a transformer continue so long as the current is flowing into the primary circuit; consequently a plant which runs six hours a day will only waste one quarter of the power by iron losses that it would if operated for 24 hours per day, and takes as a basis for further calculations a plant which supplies current 24 hours each week day and 12 hours on Sunday. He naturally shows considerable economy from those transformers with a small iron loss taken over a year's working.

The economy from these causes would not be so appreciable, however, in England, where the average working hours are only about 11 hours per day.

The broad conclusions one arrives at after reading Prof. Jackson's paper are, that American electricians prefer to instal transformers working at a low primary voltage, thus ensuring small iron losses, even though they must of necessity expend more capital in the increased weight of copper required in the primary mains and generating plant.

THE WORKING EXPENSES OF ELECTRIC AND CABLE RAILWAYS.*

(*Concluded from page* 309.)

In the Birmingham cable tramway we get back to cheerful associations. It more than maintains its fine traffic, and the working expenses are lower than ever. The receipts per car mile also show a falling off; but the increased mileage run more than counterbalances this, and the percentage of expenses to receipts is the lowest in the history of the line. Birminghan indeed shows the same tendency as most of the lines during the past year, in particular to a reduction in the receipts per mile run. This arises in general from a generous increase in the mileage; but this year it is apparent some other cause is at work, perhaps a larger portion of the passengers making very short journeys. The following tables show the career of the Birmingham cable line, Table X. giving the correction when the additional expenses for directors, secretary, &c., are added :—

Table VIII.—Birmingham Cable Tramway.
Per Car Mile—Pence.

Year ending	Cable haulage.	Cables and machinery.	Car repairs.	Traffic expenses.	Permanent way and buildings.	General charges.	Total.
June, 1888	3·98	...	·39	2·21	...	2·89	9·47
1889	3·38	1·8	·14	1·64	·02	1·53	8·51
1890	2·55	·96	·39	1·22	·08	·9	6·1
1891	2·41	·95	·83	1·3	·13	·71	6·33
1892	2·39	1·11	·62	1·25	·17	·64	6·18
1893	2·41	1·35	·46	1·23	·17	·7	6·32
1894	2·19	·9	·47	1·27	·37	·63	5·83
1895	1·96	·84	·42	1·24	·29	·78	5·53

Table IX.—Birmingham Cable Line—Totals.

Year ending	Expenses per car mile.	Receipts per car mile.	Per cent. of expenses to receipts.	Total expenses.	Total receipts.	Miles run.	Passengers carried.
June, 1888	9·47	17·41	54·34	£ 1,534	£ 2,820	38,900	...
1889	8·51	15·96	53·1	6,958	13,053	196,307	2,206,168
1890	6·1	13·16	46·35	11,681	25,212	459,806	4,261,050
1991	6·33	12·83	49·33	13,795	27,961	522,876	5,241,362
1892	6·18	12·2	50·65	16,001	31,585	621,210	5,922,304
1893	6·32	12·69	49·8	16,878	33,893	641,161	6,341,753
1894	5·83	12·39	47·05	16,968	36,074	698,850	6,699,476
1895	5·53	11·86	46·63	17,139	36,744	743,805	6,842,538

Table X.

Birmingham Cable Line—Corrected Expenses.
Per Car Mile—Pence.

Year ending	Total as in preceding table.	Additional expenses.	Grand total.	Per cent. of expenses to receipts.
June 1888... ...	9·47	·27	9·74	55·95
1889... ..	8·51	·27	8·78	55·01
1890... ..	6·1	·28	6·39	48·56
1891... ...	6·33	·27	6·6	51·44
1892	6·18	·22	6·4	52·46
1893... ...	6·32	·25	6·57	51·77
1894	5·83	·2	6·03	48·67
1895... ..	5·53	·15	5·68	47·89

* *Railway World.*

We now come to the Edinburgh cable tramway. Its working expenses for the last half-year are the second lowest on record, but considering the increase on the mileage compared with that of the half-year ending June, 1894, it does not come out quite so brilliantly. Still the record is a very fine one. Let the reader make for himself the comparison which we worked out last year of the great Birmingham cable traffic over a road of the same length with small traffic in Edinburgh, and, seeing that the line in the latter city figures out at very little more per car mile, he will then appreciate how cheaply Edinburgh is worked. As to receipts, considering that a reduction in fares has been in force during the half-year, and that the weather in the first three months was so bad, the revenue per car mile was kept up wonderfully. Dividends of 5 per cent. on the inflated amount of capital of the Edinburgh line are now being paid.

Table XI.—Edinburgh Cable Tramway.
Per Car Mile—Pence.

Half-year.	Motive power.	Traffic.	Maintenance of road, cars, and plant.	General charges.	Total.
June, 1890 ...	1·4	3·55	2·25	1·7	8·9
Dec., 1890 ...	1·36	3·1	2·5	1·98	8·94
June, 1891 ...	1·26	2·92	1·83	1·52	7·53
Dec., 1891 ...	1·3	2·62	2·19	1·95	8·06
June, 1892 ...	1·08	2·47	2·15	·86	6·56
Dec., 1892 ...	·93	2·52	2·0	1·67	7·12
June, 1893 ...	·97	2·6	2·04	·86	6·47
Dec., 1893 ...	·76	2·47	1·5	1·58	6·31
June, 1894 ...	·73	2·3	1·61	·69	5·33
Dec., 1894 ...	·83	2·32	1·4	1·75	6·3
June, 1895 ...	·84	2·35	1·86	·81	5·86

Table XII.

Edinburgh Cable Line—Totals.

Half-year.	Expenses per car mile.	Receipts per car mile.	Per cent. of expenses to receipts.	Total expenses.	Total receipts.	Miles run.	Passengers carried.
				£	£		
June, '90	8·9	13·32	66·82	3,721	5,570	100,319	1,169,624
Dec., '90	8·94	13·27	67·37	4,563	6,776	122,503	1,412,366
June, '91	7·53	12·24	61·52	3,828	6,215	121,827	1,316,681
Dec., '91	8·06	12·09	66·66	4,516	6,770	134,383	1,428,368
June, '92	6·56	11·12	58·99	3,922	6,648	143,443	1,421,192
Dec., '92	7·12	11·3	63·01	4,467	7,088	150,516	1,498,904
June, '93	6·47	12·0	53·92	3,921	7,270	145,000	1,549,259
Dec., '93	6·31	11·21	56·29	4,510	8,005	171,352	1,714,531
June, '94	5·33	10·89	48·94	3,863	7,885	173,791	1,697,639
Dec., '94	6·3	10·89	57·85	4,802	8,307	183,036	1,785,317
June, '95	5·86	10·56	55·49	4,298	7,750	176,102	1,780,874

We have formerly shown clearly how the results of working cable tramways over a period of years in Birmingham and Edinburgh exemplifies the way in which working expenses per mile run decrease as the mileage increases. This highly desirable feature of cable traction need not be further pointed out. The benefit to the tramway companies here goes along with the benefit to the public.

Appended are the tables of expenses and receipts per ton mile. The only point to be noted is that no comparison should be made between the two electric railways and the tramways as the determining factors are so widely different. The comparison is to be made only between one railway and another and between one tramway and another. The weights of cars on which the figures are based are the same as were stated a year ago, and the assumption for the purposes of the table is that all seats in the cars are occupied by passengers. These combined weights of cars and passengers may be briefly stated as follows :—

	Tons.
Liverpool train...	38
London train	37
Birmingham electric car	11
Birmingham cable car...	8
Edinburgh car	8

TABLE XIII.

COMPARATIVE EXPENSES PER TON MILE—PENCE.

Year or half-year.	Liverpool Electric.	London Electric.	Birmingham Electric.	Birmingham Cable.	Edinburgh Cable.
June, 1888...	...	...	...	1·22	...
„ 1889..	...	...	...	1·09	...
„ 1890...	...	...	...	·8	1·11
Dec., 1890..	...	...	...	...	1·12
June, 1891..	...	·58	·92	·82	·94
Dec., 1891..	...	·53	...	...	1·01
June, 1892...	...	·52	1·42	·8	·82
Dec., 1892 .	...	·47	...	...	·89
June, 1893...	·4	·45	1·53	·82	·81
Dec., 1893..	·35	·43	...	...	·79
June, 1894...	·35	·43	1·55	·75	·67
Dec., 1894...	·34	·42	...	...	·8
June, 1895...	·38	·43	1·87	·71	·73

TABLE XIV.

COMPARATIVE RECEIPTS PER TON MILE—PENCE.

Year or half-year.	Liverpool Electric.	London Electric.	Birmingham Electric.	Birmingham Cable.	Edinburgh Cable.
June, 1888...	...	...	...	2·18	...
„ 1889...	...	...	...	1·99	...
„ 1890..	...	...	...	1·64	1·66
Dec., 1890...	...	...	...	...	1 66
June, 1891...	...	·73	1·38	1·6	1·53
Dec., 1891...	...	·7	...	...	1·51
June, 1892..	...	·74	1·2	1·5	1 39
Dec., 1892...	...	·69	...	...	1·41
June, 1893..	·72	·69	1·49	1·59	1·5
Dec , 1893...	·48	·66	...	...	1·4
June, 1894...	·48	·69	1·53	1·55	1·36
Dec., 1894...	·52	·68	...	...	1·36
June, 1895...	·62	·71	1·43	1·55	1·32

The last of the tables show the expenses and receipts per passenger carried. The receipts are a trifle higher than the average fare as revenue from advertisements and other small items is included.

TABLE XV.

EXPENSES PER PASSENGER CARRIED—PENCE.

Year or half-year.	Liverpool Electric.	London Electric.	Birmingham Electric.	Birmingham Cable.	Edinburgh Cable.
June, 1889...	...	...	...	·78	...
„ 1890...	...	...	...	·69	·76
Dec., 1890...	...	...	...	...	·77
June, 1891...	...	1·54	1·23	·66	·69
Dec., 1891...	...	1·35	...	...	·76
June, 1892...	...	1·29	2·13	·67	·66
Dec., 1892...	...	1·15	...	...	·72
June, 1893...	1·22	1·14	1·88	·66	·61
Dec., 1893...	1·33	1·15	...	...	·63
June, 1894...	1·25	1·06	1·82	·63	·55
Dec., 1894...	1·13	1·08	...	...	·65
June, 1895...	1·29	1·16	2·49	·6	·58

TABLE XVI.

RECEIPTS PER PASSENGER CARRIED—PENCE.

Year or half-year.	Liverpool Electric.	London Electric.	Birmingham Electric.	Birmingham Cable.	Edinburgh Cable.
June, 1889...	...	...	...	1·42	...
„ 1890...	...	...	...	1·42	1·14
Dec., 1890...	...	...	...	...	1·13
June, 1891...	...	1·95	1·83	1·28	1·13
Dec., 1891...	...	1·77	...	...	1·13
June, 1892...	...	1·84	1·81	1 28	1·12
Dec., 1892...	...	1·69	...	...	1·13
June, 1893...	2·16	1·77	1·84	1·25	1·13
Dec., 1893...	1·78	1·77	...	...	1·12
June, 1894...	1·68	1·72	1·79	1·29	1·11
Dec., 1894...	1·69	1·78	...	...	1·12
June, 1895...	1·95	1·88	1 89	1·29	1·04

It is to be regretted that the London Tramways Company still maintain silence as to the working expenses of their Brixton cable line. That the costs are very low may be taken for granted, and the effect indeed is manifest on the total expenses of the company, which are now probably lower per mile run than those of any horse tramway in the country. The extension of the cable line to Streatham, now under construction, will require no additional engines, and the extra expense will be very small. This will bring the cost per car mile lower still. It is too soon to speculate when separate accounts will be published of the prospective cable lines in Edinburgh and Newcastle, but in the domain of electric railways more extensive data are certain in the future, as the Waterloo and City Railway and the Central London Railway belong to companies owning no other lines. Accounts will thus be available. At present there is no very definite prospect of obtaining the working expenses of street electric tramways operated through overhead wires. American data of a fairly satisfactory nature, are, however, now being made public.

It will be seen that there is every encouragement from the tables to look forward confidently to the future of electric railways and cable tramways in this country.

LIGHT RAILWAYS AS AN ASSISTANCE TO AGRICULTURE.

SUCH was the title of the paper which Major-General Webber read to the British Association at Ipswich. Ipswich, as the chief town of the county of Suffolk, was certainly a suitable place at which to consider light railways. To illustrate the paper, no fewer than 11 possible routes were sketched out, leading from the Great Eastern station in Ipswich outwards into the country, and amounting to 77¼ miles, all of which could, without difficulty, be worked by overhead wires from one generating station, and the refusal to allow overhead wires is, says the author of the paper, ridiculous in face of what has been done in towns like Lubeck, Essen, Chemnitz and others. The Irish light railways cannot be claimed as light railways; they are simply branches of the main lines, of which Ireland has so few, but they are not light railways in the sense we now understand the term. Major-General Webber very properly condemned the placing of railway men on the light railway committee. Such men are too hide bound to do any good; they are unfitted by their very experience on heavy lines to appreciate the light railway at a proper value, and the admission of them was fatal to anything but a mere paper report. Such is the drift of Major-General Webber's remarks, and we think he has hit the average railway man in a weak point. The railway man is all for railways and regulations, and to him the public is an unavoidable and detestable nuisance, made for pillage, but not worthy of a moment's consideration, an attitude held by all railway men, and at the bottom of poor dividends. The Major-General's own letter in the *Times* is referred to, wherein special attention is drawn to the need for light railways, and the necessity that vehicles to be run upon them must be capable of being handled by the men and horses of the farm. The lines shall, in fact, be capable of being laid into the fields to move the crops, and reference is made to their use on sugar and cotton estates.

He advocates, therefore, a gauge of 18 to 30 inches, requiring 4½ to 6 feet of ground breadth, and costing under £1,500 per mile altogether. The Portrush and Giant's Causeway electrical line is referred to as a line on a public highway which has now been 12 years at work. It differs, therefore, from the so-called Irish light railways, and is cited as an example of a railway on which steam and electrical motors have run along the highway without any abnormal rate of accident. This line of 8½ miles cost over £45,000, but the author cannot see how £29,000 of this amount could have been made up, nor, indeed, is it easy to explain this. At least, this line ought not to be allowed to be used as an argument against other light railways. Thus, for example, the Société Nationale des Chemins de Fer Vicinaux have 58 lines of a total length of 730 miles, and 900 miles projected; 615 miles are of metre gauge, and the rest of wider gauge, yet the average construction only amounted to £2,688 per mile, or, with land, £2,908, and there are 245 locomotives,

usually weighing 18 tons, but some of 30 tons weight. The working expenses were 71·31 per cent. of gross receipts, and with such heavy engines we are not surprised at this. Now, this heavy percentage of working expenses is probably a very important factor. In spite of the avoidance of cost in the shape of station expenses, signalling, &c., the working expenses are abnormally high. This shows small receipts, and where a line has small receipts, it is imperative that its capital should be small, in order that a dividend can be paid. Lieut.-Col. Addison has reported upon one of these Vicinaux railways, about 12½ miles in length, which, like all these lines, is constructed upon the road except where an occasional diversion is necessary to avoid a gradient. The line is simply raised slightly on ballast, and separated from the roadway by a kerbstone. It cannot, therefore, be used, as a part of the road, except through villages where the tramway type is adhered to. The line has a gauge of 1 metre, and the rails weigh 42 lbs. per yard, and being of Vignole's type, are simply spiked to the sleepers, which measure 56 inches × 8 inches × 4 inches. The sharpest curves are of 1½ to 2 chains radius, and there are gradients as steep as 1/20 and 1/25, while speed is limited to 18 miles in the country, and six miles in towns and villages. The 12¼ miles is covered in the 25 minutes, but one train daily each way only requires 65 minutes. The speeds are thus equal to those on main line railways to suburban London; 33 yards is allowed for the engine brakes alone to stop a train on the steepest gradients. The locomotives are of the tramway type, closed in. There are no signals, but several sidings, for loading purposes, at which trains stop to pick up loaded waggons. No tickets are issued at the passenger depôts, which are usually simply a room at an inn, where parcels can be left, and for which the innkeeper is glad to make no charge, because he gains indirectly by the business which accrues to him.

Concerning the tramways of the Charente Inferieurs, our Consul, Mr. Warburton, points out how they are choked by officialism and red tape, a fault in French management. Thus a line, of which more than two-thirds is along a road, is classed as a tramway, and as a railway, if less than two-thirds borders on the road, and so on through other arrangements, and the Consul's opinion is not favourable. But such lines are too much like ordinary railways, and are another example of the incapacity of the purely railway man to grasp the truth of the matter. Major-General Webber says that any local authority wishing to learn the truth and possibilities of the really light railway, should visit Woolwich Arsenal or Guinness's Brewery, where an 18-inch gauge, and rolling stock to match, may be compared with the ridiculous 15-ton engines on the French metre gauge lines. At Guinness's brewery the locomotives are, or were some years ago when we were there, about as large as a good sized cottage piano. They were sensible tools for light railway work, and fine examples of what can be done with really light narrow gauge lines. The Decauville portable railway is, to our mind, what is needed by the farmer to place his farm in connection with the light railway, and such connection need not be possessed in large quantity, for it can be shifted from point to point. For many crops the lines would not need to be taken into the fields, but simply into the stack-yard. Major-General Webber estimates that 200 miles of 24-inch gauge could be laid down in Suffolk, with 20-lb. rails, for £1,027 per mile, or £1,436 per mile including rolling stock, but excluding land, and he anticipates running nearly a quarter of a million train miles annually at a receipt of 1s. 6d. per mile, and he takes his stand as to expenditure at 1s. per mile, instancing, in support, the Cork and Muskerry Company's lines at an expense of 11¼d. a mile, though of 5 feet 6 inches gauge, and worked as a railway with railway expenses.

For the Suffolk lines a land expenditure of £50 per mile is suggested, and we should think this is really quite an outside figure. The total, £10,000, is suggested as properly a public charge, and the local authorities should also take charge of a sinking fund of 1½ per cent. on the capital. The total annual public cost would be ·59d. per £ added to the present rate of 18½d., and for this, the local authority would have a claim on all net profits after paying 3 per cent., say, two-thirds of remainder, a representation on the directorate, and at the end of 42 years possession of the lines without further payment. We need not repeat the quotation of Mr. Kerr's remarks on the possession by the farmer of some portable 24-in gauge line for connecting to the permanent line, further than to mention his ratio; 1 to 2 of live to dead load, in comparison with 1 to 4 as an ordinary line. This, at least, we suppose to be meant, though in our copy of Major-General Webber's paper, the ratio's are reversed. On the assumed Suffolk lines the rate per ton mile is assumed to be 2d., which may be compared with the cost to the farmer of carting the whole way.

Turning, finally, to the question of overhead construction for electrical purposes, by which all of the 77 miles out of Ipswich could be worked, this is set down as £29,000, to which the central station would add £17,000, and this total of £46,000 would only save £5,000 in locomotives in addition to the saving of coal, and though the labour is said to be the same, or nearly so, we think that there would be a saving in the item of labour. These figures assume an average of 11 trains, or one on each line running at one time. Electrical traction, therefore, is not considered as likely to pay on lines of so poor a traffic, but there is this to be said on the subject, viz., that if the light lines of the country are made to standard gauge of 18 or 24 inches, the locomotives would be saleable at all times, and electrical traction could be installed as soon as the traffic warranted this, while, with centres like Ipswich, there is the consideration of securing day loads for lighting stations. Obviously, however, the heavy cost is in the conductor, and this must be met by a sufficiency of traffic.

If 2-feet gauge is, as so often claimed, nearly as costly as 4 feet 8½ inch gauge, why are there so many hundreds of miles in Bolivia, India, Burmah and the colonies, of 20 to 36 inches gauge?

London is given up by the author of the paper as hopeless. Forty years hence he anticipates the engineering bankruptcy of London. Possibly he refers to the idiotic way in which the substratum of London is allowed by Parliament to be pierced at any depth, and in any direction, by irresponsible and ignorant promoters without any reference to ultimate connection of the short bits, but the country towns are still free of this brand, and have their chances yet, and should look ahead in the direction of boundary extension, extending their jurisdiction over a wider suburban area, and spreading their population out along lines of travel past houses with some extent of land round each. Then will be the time for the electrical lines, just as now they have them in America, where cheaper land has encouraged more straggling towns. The battle of the gauges, which fixed the 4 feet 8½ inches as standard, was well enough at the time, but it should not now be allowed to tie our hands in respect of mere feeder lines. Of what possible good would a portable section of standard gauge be to a farmer? but there is sense in the portable railway of the Decauville type. When we think that the standard gauge permits of the use of locomotives which weigh 100 tons, we may well question the need for such a gauge in the scheme of a light railway, such as could be run from 8 to 10 miles along the six to twelve roads which extend outwards from most of our towns.

With a wide gauge it is difficult, indeed, apparently impossible, to build light stock. To begin with, the very width apart of the wheels demands a heavy axle, heavy car framing, and heavy locomotives. If agriculture is to derive any benefit from the light railways, they must be really light. They must not be simply thin paper editions of standard gauge lines cut down to the danger point of strength, but carefully designed combinations of track and rolling stock entirely divorced from all idea of their utilisation by standard vehicles, and though we would not insist on the roadside portions being of the portable track type put together in sections, we see no reason why this plan should not be followed, and it is imperative that it should be so followed as regards the portions laid by the farmers themselves. The idea of a farmer laying anything of the fashion of a railroad will be utterly repugnant to the average railway man, and if we keep this before us we can better comprehend the Major-General's objection to the presence of railway men on the Light Railway Committee. We can scarcely doubt that something will be done after all, but it is very difficult to move the farmer out of a groove, and we expect to see an extension of suburban tramway system for the dwellers in cities to reach the country sooner than the construction of lines to enable the countryman to reach the cities.

ELECTRO-DEPOSITION OF BRASS.*

By FRANK SUTTON, E.E.

(*Continued from page* 334.)

The voltage was first applied very low, then gradually increased, and was kept constant for each deposit. After a sufficient amount was deposited, it was removed by dissolving in a little nitric acid, then the experiment was continued. The following things were kept account of :—

1. Impressed E.M.F.
2. Impressed current.
3. Temperature.
4. Counter E.M.F.
5. Colour of deposit.
6. Any change that took place.

The results are shown in Table V.; as will be seen, nothing took place until a little over 1 volt was reached, when Cu was deposited.

At 4 volts there was only 6 per cent. of Zn.
„ 10 „ „ „ 8 „ „ „

platinum. Now, in the case of the cyanides, the heats of combination are very nearly the same; the C.E.M.F. is nearly the same, and is also very low. These two salts will alloy well together.

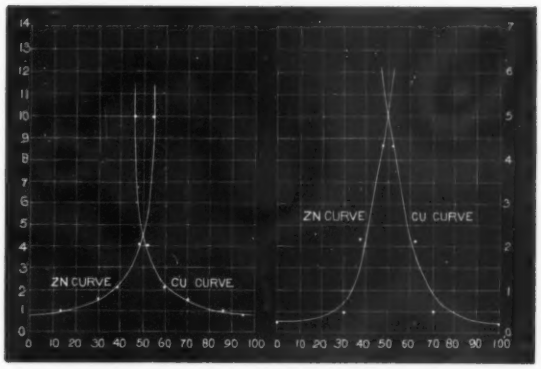


Fig. 3.—Percentage of Zinc and Copper.

Fig. 4.—Percentage of Zinc and Copper.

Table II.

Same solution as before. Platinum cathode, platinum anode. Size of plates, 5 cm. × 2·5 cm. Distance between plates, 7 cm.

	E.M.F.	B.E.M.F. reading.	B.E.M.F. $c = \frac{E-e}{R}$	Current.	$E-e$ reading.	$E-e$ formulæ.	Copper.	Zinc.	Temp.	Colour.
1	·25	...	...	...	...	...	...	...	27°	...
2	·50	...	...	...	...	...	...	...	„	...
3	·75	...	..	...	...	...	trace.	...	„	Copper.
4	·85	·8	·79	·01	·05	·06	95	5	„	„
5	1·00	·7	·7	·05	·3	·3	87	13	„	Red Brass.
6	1·6	1·2	1·25	·07	·4	·35	70	30	„	Good brass.
7	2·1	1·5	1·50	·1	·6	·6	61	39	„	„
8	4·1	1·75	2·30	·3	2·35	1·80	51	49	„	Very pale.
9	10·	...	...	·8	...	...	46	54	„	Uneven.
10	18·	...	...	1·00	...	...	47	53	„	„

Fig. 6 shows the relation between the amounts of Zn and Cu deposited and the E.M.F.

The next experiment was with a strongly saturated solution of pure cyanide of copper and cyanide of zinc, and was conducted exactly as the last one, the two electrodes being

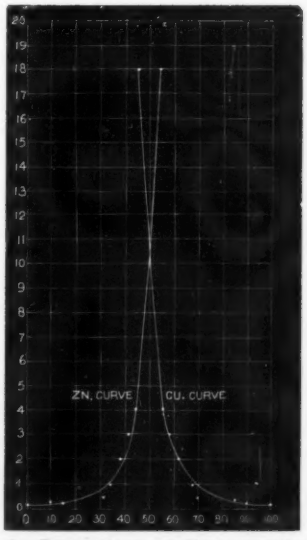


Fig. 2.—Percentage of Zinc and Copper.

In Table I. we see that the deposit was formed at as low a voltage as ·15, but only Cu; when ·25, both were deposited. This gave about 90 per cent. of Cu and 10 per cent of Zn. The deposit was very good until a little over 5 volts was reached, then it commenced to be uneven and streaky and did not adhere well. One peculiar thing was that in case of 18 volts there was more Zn than Cu. This was explained in the first part of the article. The relation between the E.M.F. and the amounts of Cu and Zn deposited are shown in fig. 2.

In Table II. the brass anode was changed to a platinum one. In this case we see that there was nothing deposited until ¾ of a volt was reached. This was on account of the resistances of the electrodes being changed, but this seems to take place only on the lower voltages, for when it was raised, the results seemed to catch up with Table I. (fig. 3.)

The specific resistance of this solution was 10·8 ohms, or about one-half of the sulphate solution.

The next experiment tried was a brass solution, such as is used in electroplating establishments. It was made in the following manner:

$Cu\ So_4$ 57 gms.
$Zn\ So_4$ 67 „
$H_2\ O$ 2·35 litres.

These were mixed together and dissolved. The solution was p.pt. with 425 gms. of carbonate of soda, and to this was added 212 gms. of carbonate of soda + 101 gms. bisulphide soda + 2·35 litres H_2 O. After this was done, ordinary K Cy was added until everything was dissolved; the solution was then filtered.

(*To be continued.*)

* *Electric Power*, New York.

NEW PATENTS—1895.

11,728A. "An improvement in voltaic batteries." W. Shaw. (Date claimed under Patents Rule 19, June 17th, 1895.) Dated September 6th. (*Complete.*)

16,427. "Improvements in electric bell pushes." E. P. C. Giroudard. Dated September 2nd.

16,439. "Improvement in dynamo-electric machines." F. H. Royce. Dated September 3rd. (*Complete.*)

16,450. "Improvements in stage or like arc lamps for alternating currents." A. Sykes. Dated September 3rd.

16,482. "Improvements in electric and pneumatic bell-pushes." H. G. Warner. Dated September 3rd.

16,494. "Improvements in and relating to supports for overhead electric conductors." W. R. Lake. (Communicated by C. J. Goodwin, United States.) Dated September 3rd.

16,521. "Improvements in and connected with the overhead system of electric traction." W. C. Bersey. Dated September 3rd.

16,557. "Electro-deposition of gold and silver." E. Andreoli. Dated September 4th. (*Complete.*)

16,562. "Improvements in multiple electrical switches." H. Hirst. Dated September 4th.

16,569. "Improvements in the manufacture of electrodes for voltaic batteries." L. Epstein. Dated September 4th.

16,582. "Improvements in storage battery plate." F. N. Tilton. Dated September 4th.

16,635. "Improvements in the regulation and construction of electric motors." W. L. Pakenham and J. C. Howell. Dated September 5th.

16,643. "Improvements in motor vehicles for single-line elevated railways." F. B. Behr. Dated September 5th.

16,651. "Improvements in electric glow lamps." E. Rosenberg, of the firm of H. M. Salmony & Co. (Communicated by the firm of Von Severen & Schwabe, Germany.) Dated September 5th.

16,659. "Improvements in and relating to electric railways." R. Belfield. (Communicated by the Foreign Electric Traction Company, ———.) Dated September 5th.

16,700. "Apparatus for supplying electrical energy to tramcars from underground conductors." Siemens Bros. & Co., Limited. (Communicated by Messrs. Siemens & Halske, Germany.) Dated September 6th.

16,701. "Contact apparatus and appliances in connection therewith for facilitating the passing of tramcars over crossings and switches in electrical tramways with underground conductors." Siemens Bros. & Co., Limited. (Communicated by Messrs. Siemens and Halske, Germany.) Dated September 6th.

16,702. "An element for secondary voltaic batteries." P. Vandersmissen. Dated September 6th. (*Complete.*)

16,736. "Improvements in or connected with apparatus for extracting gold and silver from cyanide solutions by electricity." J. Pfleger. Dated September 6th.

16,737. "Improvements in or connected with electrical apparatus for extracting gold and silver from cyanide solutions." J. Pfleger. Dated September 6th.

16,742. "Reversible rotary incandescent electric light switch." J. W. Fielding. Dated September 7th.

16,794. "Improvements in and relating to the calibration of electric measuring-instruments." S. Evershed. Dated September 7th.

16,796. "Improvements in electro-magnets." I. A. Timmis. Dated September 7th.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1895.

1,512. "Improvements in electric arc lamps." Sir C. H. A. F. L. Ross. Dated January 22nd. Consists of a frame formed of two parts suitably insulated from one another, and each part carries, on pivots, a rocking frame provided with tubes to receive the carbon. The main frames also carry electro-magnets, which are energised by the current, and so placed as to act on the carbon holders, and rock them, in order to separate the positive and negative carbons and thus produce the arc. 1 claim.

1,797. "Improvements in filaments and carbons for electric lamps." P. Stiens. Dated January 25th. Consists in treating the carbon filaments of incandescent lamps with burnt boric acid. 4 claims.

4,658. "Improvements in magnetising and demagnetising apparatus." C. Houlgrave. Dated March 5th. Relates more particularly to those devices used in the magnetisation and demagnetisation of watches, compass needles and similar articles; and it has for its object to provide a device of this nature which shall be cheap and simple of construction, accurate of operation, and which, moreover, may be operated equally well with either a continuous, pulsating, or alternating current. 15 claims.

5,798. "Spring-winding apparatus for printing telegraph and other instruments." J. Burry. Dated March 19th. The object of this invention is to use the current in winding the main-spring or weight in an economical and efficient manner. 7 claims.

6,008. "Improvements in springs for electrical conductors." Siemens Bros. & Co., Ltd. (Communicated from abroad by Messrs. Siemens & Halske, of Berlin.) Dated March 22nd. The spiral spring forming the subject of the invention is wound double from the centre, presenting both ends at the periphery of the spiral. This spring combines the advantage of secure metallic connection between the two connected parts which is given by the ordinary blade spring, with the advantage of the great flexibility, which is a feature of the spiral spring.

6,163. "Plate for secondary voltaic battery." W. A. B. Buckland. Dated March 25th. Claim:—A plate for secondary voltaic battery, consisting of a conducting frame made with a number of parallel bars, on which are strung strips of celluloid or equivalent material, held in position by flattening the portions of bars between the strips, the plate thus prepared being filled in and covered with active material, substantially as described.

6,171. "Improvements in multiple switches for use with double telephonic leads." F. Stock. Dated March 25th. Has for its object to provide a multiple switch arrangement for double telephone leads, in which the keys with two springs usually employed in single telephone leads can be also employed with the double leads, with the result that the space available for the several switchboards will be capable of receiving a large number, say, 10,000 keys, whilst in the case of existing installations, the change from the single lead system to the double lead system, which is more and more felt to be an urgent necessity, can be made with ease, and at not too great a cost. 6 claims.

6,430. "Improvements in conduits for electrical conductors." J. F. Cummings and W. C. Yawkey. Dated March 28th. Particularly consists in the construction of a duct or tube, comprising an outer metallic pipe, and an inner lining of wood or similar material, made in sections arranged in tubular form, and forced into the outer pipe, which acts as a sleeve or binder to hold the lining in shape. 1 claim.

6,681. "Improvements in or relating to electric switches or circuit controllers." J. M. Cronin. (Under International Convention.) Dated September 22nd, 1894. The switch is provided with an auxiliary switch or controller co-operating with the movable members of the main switch, whereby a series or group of translating devices or lamps may be retained in circuit with the source of supply, while other lamps normally in circuit therewith, may be shunted out of the circuit. 2 claims.

6,756. "An improved mode of connecting the parts of a telephone apparatus." A. J. Boult. (A communication from P. Rabbidge, of Sydney.) Dated April 2nd. The object of this invention is, first, to dispense with the mechanical automatic switch appliance and to arrange the circuit so that the transmitter-receiver and battery shall remain constantly in the line circuit. Secondly, to arrange the call circuit whereby two trembling bells (one at each station) can be used and made to call at the same time. 5 claims.

7,548. "Apparatus for controlling electric currents." Siemens Bros. & Co., Ltd. (Communicated from abroad by Messrs. Siemens and Halske, of Berlin.) Dated April 13th. Relates to means of protecting electric motors or other electric apparatus from injury that might result from currents of too great strength.

8,011. "Improvements in the electrodes or plates of electric storage batteries." G. Hubener. Dated April 23rd. Consists in melting together dinitrobenzol, mononitrobenzol or bromonitrotoluol, tar or its derivatives, mononitrocellulose, and cellulose meal, and adding thereto lead oxides or other suitable metallic oxides. 2 claims.

8,393. "Improvements in and relating to the electric lighting of railway vehicles." M. Moskowitz, L. D. Adler, A. S. Adler, and T. W. Myers. Dated April 27th. Has for its object to provide a dynamo having two or more armatures arranged on the car wheel axle and connected in series, to produce great tension or pressure from a comparatively slowly rotating car wheel axle. 5 claims.

8,394. "Improvements in means for equalising the electromotive force of dynamos." M. Moskowitz, L. D. Adler, A. S. Adler, and T. W. Myers. Dated April 27th. Consists of two electrical machines or apparatus, arranged side by side on one base, and having one shaft extending through the armature of both of said machines, one machine acting as a motor to operate said shaft, and receiving its power directly from said dynamo-electric generator, the electromotive force of which is to be maintained constant, and said second machine acting as a dynamo-electric machine, its armature and magnetic field being so coupled with the fields of the dynamo electrical generator, that its electromotive force will oppose that generated by said dynamo generator in the main circuit. 2 claims.

9,513. "Improvement in incandescent electric lamps." W. H. Sheppard. Dated May 14th. Relates to an improvement in electric lamps, which is more particularly adapted to be used as a desk lamp, and may be readily set to shed the light in different directions. 2 claims.

9,703. "Improvements in electrically transmitting power, or signals, or the like, to or from moving vehicles or other objects." J. Y. Porter. Dated May 16th. Relates to improvements in communicating, signalling, &c., to or from moving objects, by means of a trolley wire.

9,704. "Improvements in switch apparatus for electric railways or tramways." J. Y. Porter. Dated May 16th. The switch is normally maintained in an open position, so that the car would be shunted if it passed over the portion of the track where the switch was located while it remained open, and thus prevent a collision with the passing car or cars in a direction across its own track. 4 claims.